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West Bengal.

Input-Output Analysis in Public Education

Input-Output Analysis in Public Education

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To Sharon, David, and Klara

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Preface

There is increasing awareness of the need to apply rigorous management techniques to assist education decision makers in allocating scarce resources. The need for greater educational productivity has been placed into a sharper focus by the fiscal problems confronting education. The basic reason for such fiscal problems has been the ever-increasing costs of education—despite a reduction in the rate of increase in enrollments and, in some cases, an absolute decrease in enrollments—which are related to higher input costs despite little or no improvement in educational productivity. When costs increase but productivity remains essentially constant, costs per unit of output must increase, and therefore schools must seek increased public support. In an effort to reduce the burden of government operations, economy minded legislatures and boards of education are reluctant to increase tax revenues in proportion to the increase in educational costs. Something, therefore, must "give." Either the level of production must decrease, or ways must be found to produce the same output from a smaller input base.

The assumption underlying this study is that there exist some possible ways to reduce input costs without reducing the level of educational output—or, alternatively, to produce a greater level of output utilizing the same amount of inputs. This means, of course, that management decisions in education have not been optimal. This is not to say that educational administrators have necessarily been lax, but rather that the nature of educational production is so complex that even the best administrators would be unable to arrive at the optimal decision.

The study therefore explores some techniques that could assist education managers in their attempt to arrive at more optimal input and output mixes.

No panacea is offered here; only suggestions that would require thoughtful and searching analysis along with serious data collection are proposed.

The first part of this study consists of Chapters One through Four, which provide an overview of the input-output concept in relation to its employment in the educational setting, along with a review of the literature on the educational production function. The second part explores the production process of secondary education for a sample of Pennsylvania secondary schools. A description of the Pennsylvania Plan is contained in Chapter Five, followed by a simultaneous-equations analysis in Chapter Six and the construction of an output index, based upon the technique of canonical correlations, in Chapter Seven. The final part consists of a brief chapter on the use of mathematical programming, in particular goal programming, as an alternative tool for educational input-output analysis.

Although I must assume full responsibility for the entire work, primary responsibility for Chapters One, Two, and Four was shouldered by Dr. Stephen Millman, and Chapter Eight was contributed by Mr. It-Keong Chew.

This study evolved from a doctoral dissertation completed by Dr. Rodney J. Kuhns at the Pennsylvania State University in 1972. The data used here were compiled by Dr. Kuhns, in cooperation with the Pennsylvania Department of Education, and single equation analysis was reported in Kuhns's dissertation (1972). The work presented in Chapters Six and Seven is an extension of his work, providing for the first time a comprehensive simultaneous-equations system describing educational production in a secondary school system. Our ability to conduct the study was conditioned on the coopreation of Dr. Kuhns and officials of the Pennsylvania Department of Education, to whom we are very grateful.

An earlier version of the Pennsylvania model is contained in a final report to the National Institute of Education, entitled "Management-Oriented Approaches to Assess Input-Output Relationships in Secondary Schools." I am grateful to the National Institute of Education for financial support and to the staff of the Institute for Research on Human Resources, The Pennsylvania State University (where the study was conducted) for competent cooperation.

I would also like to thank without implicating my former colleague Teh-wei Hu for reading an early version of the manuscript. Special thanks are due to Michael J. Foxworth and Lloyd R. Drown, of the Management Science Center, College of Business Administration, University of South Carolina, for performing intricate programming and computer analysis to derive the set of reduced-form coefficients and their respective asymptotic standard errors, reported in Chapter 6 and Appendix Table A-5. Others who aided in the production of the manuscript at the University of South Carolina include Harry Miley, Charles Melton, and Cathy Price.

I would be remiss if I did not thank my wife, Sharon, not only for her patience and understanding during the long hours it took to produce this work but also for reading, proofing, and commenting on every chapter of this book, and helping in the preparation of the Index.

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May, 1975

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Chapter One

The Assessment of Educational Effectiveness

Great ferment is currently evident in discussions of new directions for the schools and for the selection, retention, and reward structure of those who will carry out these new directions. For the first time, individuals are attempting to specify aspects of the educational process in terms of actual outcomes of those who exit the system vis-à-vis the resources that are used as inputs into the system. The stress on performance criteria and behavioral competencies bodes well to overturn past emphasis on time spent in school, summation of credit hours, and the like.

Clearly, such an approach is a radical departure from past functioning, and the road ahead is still not totally visible to the interested viewer. Despite the uncertainty, current acceptance of the need for movement toward competency-based education indicates at long last that many are willing to advance the ability to quantify the nature of the educational process in terms of the flow of energy through the system vis-à-vis the output. We have come to see that the traditional academic bookkeeping has failed to give us any idea of what has entered, what has been transformed, and what has emerged. We have talked in terms of global objectives seldom amenable to measurement—or even, in some cases, definition.

Economists have for some time been vitally interested in the flow of resources through organizations and institutions of various kinds. While those outside economics have visualized the economist as concerned only with the flow of money units, economists themselves have been studying resources of all kinds—products, information, and human resources. The new directions in education in many ways represent application of principles that economists have developed.

More than any other single factor, what has become known as the generalized emphasis on "educational accountability" has forced educators to view the educational process anew from the perspective of efficient use of resources in transforming the variety of exogenous and endogenous inputs into a set of socially desired outputs. The tools of the economist, more than those of any other discipline, appear to offer the most promise in the current context.

The focus of this chapter is upon specification of the various extant models for analysis of the educational process. Following discussion of the models, attention is directed to an in-depth delineation of the origin, value, and uses of the economist's main contribution to assessment of educational impact—the so-called "input-output approach."

A SUMMARY OF APPROACHES TO EDUCATIONAL ASSESSMENTS

Any broad categorization of diverse theoretical orientations from separate and largely discrete disciplines is necessarily somewhat arbitrary, and the scheme presented here is no exception. This survey and system of categorization may differ substantially from those posited by other authors. However, in establishing the typology that follows, the criteria used for organization are those by which we would evaluate any specific theory. Specifically, we have asked of this typology: Is it inclusive? Is it consistent? Is it valuable heuristically? Is it parsimonious? In contrast to certain existing schemata, we believe the present approach responds affirmatively to all these queries.

We conclude that it is most appropriate to see the literature on educational effectiveness as composed of five separate and quite mutually exclusive avenues of inquiry. These approaches are presented and summarized in Table 1-1.[a]

The Literature of Educational Reform

In recent years the professional and popular presses have bristled with what can best be described as a radical critique of American education. Such writers as Holt (1964, 1967, 1970), Illich (1971), Kozol (1968), and Silberman (1970) have presented a picture of the state of education that would necessarily call for major overhaul and reconstruction of our existing educational structures. Substantively separate from the thoughts of these writers, but still within the context of a radical critique, are those who call for a major commitment to the principles of performance contracting or of educational voucher systems.

Commonly, although not universally, those calling for the types of major

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[a] This analysis draws heavily on the work of Averch et al. (1972).

Table 1–1. The Approaches to Assessment of Educational Effectiveness

Approach	*Disciplines with Which Commonly Associated*	*Key Words Commonly Associated*	*Research Methodology Customarily Employed*	*Comments*
The literature of educational reform	Educational philosophy Cultural foundations of education	Crisis in education Experiential (humanistic) education Alternative (radical) education	Participant observation, rumination, reflection	Approach is ex post facto, using no statistical or experimental procedures, not easily replicated or amenable to policy decisions.
Learning theory research	Educational psychology Experimental psychology Testing & measurement Curriculum & supervision	Operant & respondant conditioning Behavior modification Training groups	By use of experimental control & manipulation, attempt to determine individual effect of experimental treatment on student behavioral change	Although much rigor is apparent in procedures employed, studies are often too "micro" to have important policy implications for major instructional change
Social-cultural *Gestalt* approach	Sociology Political science Organizational behavior	Community influences Socialization	Generally, case study method is applied	While approach provides a richness of anectdotal detail matched only by the educational reformers, lack of quantitative data limits policy implications
Analysis of major interventions	Education policy studies	Title I (ESEA) or Headstart type of research	Through massive doses of additional resources, attempt to influence behavior or skill level of students. Commonly change many inputs rather than limited number	Often difficult to determine the separate effects of individual program changes implemented. Requires substantial seed money.
Input-output studies	Economics Management Science	Systems approach Education production function Cost-effectiveness studies "Coleman-type" research	Statistical manipulation of multiple resource and outcome variables to simulate the effect of policy decisions that could be made.	Provides most total view of entire educational process capable of providing quantified data susceptible to policy decision making.

educational reforms discussed above, argue for their specific recommendations a priori rather than from the basis of hard data generated and analyzed. The stress is upon subjective judgment. Such a bent cannot be denied out of hand; however, the approach makes replication and consequent checks of validity and reliability difficult, if not impossible. Implications of such "soft" analysis are thus not directly amenable to making an effect on policy decisions in any global sense. Nevertheless, these authors have awakened many to the need for more adequately addressing research to issues in education.

Learning Theory Research

What is here being called the learning theory approach to educational research includes attention to both operant ("Skinnerian") as well as respondent ("Pavlovian") conditioning, along with more humanistic approaches, each of which attempt to explain the process or processes through which learning is hypothesized to occur. To the extent that the amount of individual learning is measured, it is measured inferentially from an observed change in knowledge, attitude, or skill over some specified time segment. By controlling for exogenous factors (such as differences in "innate abilities") we can attribute with relative safety that the residue is a function of some planned series of active interventions and exposure to resources that we collectively call the formal educational process.

Learning most assuredly also occurs through the everyday maze of random or vicarious stimulation. Some would even suggest that the larger part of significant learning activities occurs in such situations. Such learning is excluded from analysis here because it is substantially unplanned, idiosyncratic, and not directly amenable to accurate observation and analysis. While education, wherever and however gained, would be expected to affect individual outcomes, this analysis is restricted to education as a function of intentional school activities.

Psychologists of all different professional stripes have attempted to come to grips with aspects of the educational process. Much recent attention has been focused on "behavior modification" derived out of the behaviorist (stimulus-response) orientation to psychology. Other approaches stressing empathic understanding, facilitative genuineness, sensory awareness, and other affective components have resulted in what are variously called human potential education, sensitivity training, or encounter group activities.

Between these visible extremes lies a large middle ground. Almost universally, however, attention is directed to personal and environmental conditions as they influence change in individual behavior. Such a focus is no doubt long overdue. However, research on learning theory tends to be more morphogenic (idiographic) than nomothetic. That is to say, research is focused on small scale individual experiments rather than comprehensive studies of multiple influences.

While there is nothing wrong with this perspective (no other approach would uncover the variables discerned) results of such research do not present educational policy makers with the type and quantity of information with which readily to make decisions concerning the deployment of human and fiscal resources. Results of learning theory research could and do specify the need for special developmental (i.e., "compensatory") programs or other special services. They would be of relatively less value in structuring the nature of general programs and services for the vast body of students.

Social-Cultural Gestalt

Those identified with this approach would study a school—or more likely a school system—by observing the interrelations among teachers, staff, students, and the larger community. Such features as span of control, unity of command, and other characteristics of "closed system" management science would be stressed in terms of internal relations.[b]

While sociologists of this orientation would likely look at interpersonal relations and social structures inside and outside the system, political scientists would stress the relationship of outside events to internal dynamics. The most common mode of analysis for all of this research would be the case study. As with the literature of school reform, there is typically with this approach no manipulation of variables either statistically or experimentally. It is, therefore, difficult to posit causality or even correlation. While policy implications may emerge, it becomes difficult to test validity or reliability of results through replication.

Analyses of Major Educational Interventions

A productive line of inquiry, which has seen much recent use, is the analysis of changes in student performance following massive interventions through the device of new programs commonly funded by an infusion of federal dollars. The attempt would not generally be to change a single educational resource, but rather to alter the total milieu of the school. Title I of the Elementary and Secondary Education Act of 1965 and the Head Start Program are the most noted examples of such large scale intervention. Individual school districts and various state systems have conducted similar programs, although, naturally, of smaller magnitude.

[b] This is contrasted with "open system" management often associated with input-output studies; see Chapter Two.

One would expect, merely from a knowledge of the "Hawthorne effect" and from the spillovers and spinoffs of increased operating and equipment funds, that improvements of some magnitude would be clearly apparent. The results have not been so nearly unequivocal.

It should be pointed out that, in contrast to the other approaches discussed here, this methodology is both a treatment and an analysis. Since the majority of intervention projects have aimed at amelioration of the learning difficulties and disabilities of low income (commonly minority) students, we can be less than certain about the effective impact of the educational innovations as well as the appropriateness of the measurements made of impact. We have learned that culturally different students not only may need different instructional approaches, but also that standardized measures of cognitive achievement are likely to be sensitive to a pupil's cultural background. (Conceptual and operational difficulties of measurement are discussed elsewhere in this book.)

Comparisons of the intervention strategy with other lines of research are tenuous at best, because of the active role of sizeable differences in funds involved. Since the main aim is large scale change directly, rather than research suggesting possible large scale change at a later date, and since such significant quantities of "outside resources" may never again be available for use by the schools, intervention studies must necessarily be relegated to a special category. In any case, this avenue of research is not available to the individual scholar seeking to replicate the process.

INPUT-OUTPUT STUDIES

Having briefly discussed other approaches to the measurement of educational effectiveness, the remainder of this chapter is devoted to a general discussion of the origins of and rationale for input-output studies in education.[c]

The input-output mode of analysis in education is of recent vintage, and in part reflects a general need to come to grips with the concept of "value added."[d] This quest for a determination of the process effects of "production" relative to input and output is not restricted to the educational arena, but is rather a part of the type of inquiry being undertaken in many sectors of contemporary society.

The effort being made to fit an educational production function to activities of the schools follows that which was accomplished some years ago in the for-profit enterprises in the economy. While the specific methodology employed in analysis of industry needed to be modified somewhat, relevancy of the concept to education was demonstrated through an effort to apply characteristics applicable to other "complex organizations" to the educational process. Education could no longer purport to be an organism unlike any other during a period in which systems analysts were showing commonalities among all types of systems–social, industrial, and biological.

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[c] A theoretical discussion relating input-output studies to general systems theory is contained in Chapter Two.

[d] See, for example, Hodgkinson (1972).

In its most basic form, the process of input-output analysis is a research strategy through which one attempts to measure changes in system output(s) brought about by changes in the quantity and quality of system inputs. Through manipulation and analysis of system costs (financial, human, and informational) and of system benefits (explicit and implicit), one is able to better understand the nature of the transformation process taking place.

Theoretically, one could accomplish such a procedure through actual experimental manipulation of inputs. As a practical matter, however, since some human inputs are not susceptible to experimental change, and since others could not ethically be changed to the detriment of living human beings, input-output studies most typically rely on statistical manipulation.

Blalock (1960) indicates, and other statistics texts confirm, that statistical manipulation and control are directly analagous and comparable to actual manipulation and control of subjects (or resources) through experimental techniques–the approach most commonly used by social scientists. However, by statistically controlling for the influence of selected variables (and possibly extracting totally the effect of others), we are able to simulate changes that might not otherwise be possible without irreversible damage or serious premature fixation of individual subjects. Additionally, statistical manipulation can be accomplished after the fact (sample characteristics permitting), thus providing a fruitful area for later research.

Input-output studies appeared early in manufacturing industries. Heim (1972) points out the reasons why the methodology was not readily adapted to service industries generally, and to education in particular. First, the approach is most easily conceptualized when a specific, agreed-upon output can be measured directly rather than inferentially. Second, in regard to education, there is the difficulty of clearly separating school and nonschool variables that interact to create the system output. Third, such analyses are extremely difficult where there is a substantial lack of agreement about what the system outputs are or should be. It might be added parenthetically that lack of consensus about the outputs makes discussion of the process by which to elicit the outputs problematic at best.

Heim (1972) concludes:

> As a result of these and other forces, proportionately less effort has been extended to the question of input-output relationships in the education industry than is typical of industries producing more tangible products. Considering the size and importance of the education industry, the lack is especially striking (p. 10).

As more educational resources are scrutinized within the input-output framework, more uses are being found for input-output techniques. The next chapter traces the relation of input-output studies to open systems theory and provides some uses of the technique as a management tool, particularly at the school district and postsecondary education level.

Chapter Two

Input-Output Analysis: A New Perspective for Education

Having just passed through a period of great growth at all levels, American education has most recently shifted its focus from issues of quantity to those of quality. A decline in the school age population, combined with the emergence of other competing societal priorities, have made educators aware that they will be increasingly called upon to demonstrate that the output of formal education is commensurate with the magnitude of inputs being committed to educational processes.

Educational inputs and outputs have been notably difficult to specify—not to mention the problems of quantifying them once some degree of consensus has been reached about their mere identification. As Katzman (1971) points out, the determination of whether particular schools have performed satisfactorily in the past has been made in two basic ways: one could either look subjectively at the school setting and try to "feel" whether it appears to be working well, or one could attempt to make objective judgments about the resources being consumed and the product being put out. The former is clearly the most commonly used approach and has a long history of evolution; however, the latter method is the emerging approach and the one with which educators will need to deal if they are to justify enrichment of educational programs in the years ahead.

It must be understood that problems remain in making educational inputs and outputs operational and in developing a true educational production function. For example, in studying the effects of schooling on equality of opportunity, Jencks and his associates (1972) explain why they were forced to use standardized test scores as a measure of educational attainment. They wrote, in part:

> We have looked at cognitive skills, as measured on standardized tests. . . .

> We have not looked in any detail at habits, values, or attitudes. The reader should not infer that we think test scores more important than values or character. We take a dim view of test scores, both as measures of schools' effectiveness and as measures of individual talent. But while cognitive tests have many obvious defects, most measures of attitudes, values, and character structure are even worse. In the absence of evidence, theorists must rely on intuition and personal experience. These have proven a poor guide to the one thing we *can* measure, namely, cognitive skills (p. 12).

Jencks's example is important to the comprehension of what follows because it argues that we must use indices, even though they are less than perfect, on the assumption that what information they do provide is better than having no objective information upon which to base important decisions. While we may still be far from the ultimate goal, each tentative step brings us closer to our objective.

THE EMERGENCE OF INPUT-OUTPUT STUDIES: A SYSTEMS PERSPECTIVE

Until the very recent past, educational institutions had not regularly undergone the type of critical scrutiny familiar to other "complex organizations"—notably the for-profit corporate structure. Education, it was said, was so different from the production processes in other segments of the economy that principles of a general nature about the structure, functions, and operations of other organizations would not apply to educational institutions. In reviewing the available research on the organizational characteristics of American education, Anderson (1963) concluded that:

> . . . the literature in this field was largely reminiscent, anecdotal, or hortatory, and what passed for research was largely of the normative survey variety. . . . The procedures of the research or its findings did not tie in, in any systematic way, with what is being called a theory of organization or a science of management (p. 1).

Ikenberry (1972) points out that the traditional inability to consider education, particularly higher education, within the context of general organizational theory has been due purportedly to the following factors: (1) lack of clarity in the specification of specific, stable missions, goals, or objectives; (2) extreme decentralization of academic authority within institutions; and (3) the disproportionately high number of professional employees—that is, faculty and other professional staff.

However, as the number of other service industries in our society has increased, it has become apparent that institutions other than schools share many of these characteristics and are still amenable to objective analysis. Some changes in terminology are needed to conform to different purposes and rationale, but much can be gained from application of the methodology developed for judging the effectiveness of functioning organizations in general.

Willingness to examine the effectiveness of educational institutions in terms of use of resources vis-à-vis outcomes has come about, in large part, due to acceptance of a systems perspective of education in line with general systems theory. A brief discussion of the development of systems theory would therefore be useful.

SYSTEMS THEORY

Churchman (1968) defines a system as "a set of parts coordinated to accomplish a set of goals" (p. 29). In a more detailed fashion, Hall and Fagen (1968) describe a system as "a set of objects together with relationships between the objects and their attributes" (p. 81). They further define objects as the components of the system, attributes as the properties of the objects, and relationships as those things that "tie the system together" (p. 82).

The value of a systems orientation is that it allows and encourages one to see the dynamic relationships that exist between the components and the environment outside the system. In analogue, one could allude to the difference between a movie and a snapshot: in the motion picture one can see not only the components and their attributes but also their paths of movement from one state to another. Rather than a static picture, the systems approach attempts to show and account for "flow of energy."

Increasingly, the attempt is to view organizations as open systems—that is, systems that interact with their environments. While the concept of open systems originated in the study of thermodynamics (Bertalanffy, 1950), it appears to promise wide acceptance in many areas, not the least of which is management science.

Gouldner (1959) introduced the terms "rational" and "natural" systems into the management literature to correspond roughly with the physical concepts of closed and open systems, respectively. More recent theorists refer to closed and open systems directly. The closed system sees the organization as an instrument which can organize itself internally more or less independently of the conditions outside the system. The open system, on the other hand, is viewed as an organization which is in dynamic equilibrium, maintaining itself "in exchange of materials with the environment and in continuous building up and breaking down of components" (Bertalanffy, 1950, p. 23).

Authors generally associated with the closed system approach include Henri Fayol, Frederick Taylor, Max Weber, and Elton Mayo (Hall, 1972). Irrespective of their substantive differences, each of these writers strove to find the "one best way" of organizing internal structures and conditions. Two of the most well known dicta deriving from this perspective are those dealing with span of control and unity of command. The approaches identified by the terms "scientific management," "human relations management," and "the study of bureaucracy" have wide currency outside the field of management.

Relatively fewer people are familiar with the newer open systems model, however. Lawrence and Lorsch (1967) put the matter this way:

> Until very recently, organization researchers and theorists have tended to view the internal functioning of effective organizations as if there was one best way to organize. No attention was devoted to the problem in which we are interested—that different external conditions might require different organizational characteristics and behavior patterns within the effective organization (p. 14).

Katz and Kahn (1966) have written what many consider the definitive work on open systems. They state:

> The theoretical concepts should begin with the input, output, and functioning of the organization as a system and not with the rational purposes of its leaders. . . . Our theoretical model for the understanding of organizations is that of an energic input-output system. . . . Living systems, whether biological organisms or social organizations, are acutely dependent upon their external environment and so must be conceived of as open systems (pp. 16, 18).

Katz and Kahn go on to discuss the key elements of all open systems, whether biological or social. They detail the following nine separate characteristics, the headings of which are repeated in their terminology.

1. *Importation of energy.* Some form of energy is put into all living systems in terms of money, people, material, and/or information from the environment.
2. *The throughput.* Some transformation of the inputs takes place within the system.
3. *The output.* Some product of the transformation process is exported back to the environment.
4. *Systems as cycles of events.* There is a pattern within systems that is reinforced by the export of outputs to the environment. Internally, there are also patterns that recur as new elements are put in.

5. *Negative entropy.* Entropy is the process whereby systems tend to run down, decompose, etc. over time. Building negative entropy entails the development of means through which the system is replenished.
6. *Information inputs, negative feedback, and the coding process.* Information can be as much of an input as are physical commodities. Negative feedback is information that deflects the organization back to a planned course. Positive feedback merely maintains present course. A thermostat is an ideal analogue: temperature change is information to the thermostat to bring temperature back to its preset level (negative feedback); positive feedback to thermostat merely "says" that the temperature setting on thermostat needs to be changed. Coding determines what information inputs will be monitored.
7. *The steady state and dynamic homeostasis.* Though elements are constantly being imported and exported, open systems characteristically maintain a steady state. This is homeostasis rather than true equilibrium, since there is movement, but the relation of energy in and out is constant. A safety margin of energy is put in and stored to arrest entropic process.
8. *Differentiation.* Open systems tend to move toward a more complex form and a more specialized division of activities.
9. *Equafinality.* In open systems there are multiple paths to the same goal. There is no "one best way."

Principles such as these quite obviously give us a new set of parameters within which to evaluate the functioning of organizations. Since they were conceived to be of universal applicability, they do not have the closed system disadvantage of being ideosyncratic to particular settings (such as the profit sector of the economy).

INPUT-OUTPUT TECHNIQUES AS A MANAGEMENT TOOL IN EDUCATION

The basic concepts of input-output analysis have been used in different ways in the various levels and settings of our educational system. In higher education the unit of analysis has been the academic department (and other cost centers), and stress has been on dollar inputs. In contrast, input-output studies of elementary and secondary education are concerned with the individual student as a unit of analysis, with individual characteristics and sociocultural factors as inputs into the process through which competencies (the output of the system) are developed. Use of the flexible input-output approach in such diverse ways lends to the overall heuristic value of the concepts.

Since the emphasis of the present study is on the explanation of student performance in the elementary and secondary school setting, use of input-output techniques as a financial management strategy in higher education will be discussed here only briefly before delving directly into the topic at hand. While input-output studies of higher education conceived of as management tools are a more limited view of the total utility of the approach, they do demonstrate the variations of the theme in education as a whole.

Rourke and Brooks (1966) believe that there has been a "managerial revolution in higher education" under way since the early 1960s. In their view, the new approach to higher education administration has come about due to: (1) expanded use of computer assisted records systems; (2) extensions of institutional research capabilities; and (3) the adoption of new management tools originally used in other "complex organizations."

Most characteristic of the new management tools applied to higher education is the Planning, Programming, Budgeting System (PPBS). First implemented in the Department of Defense (Hitch, 1971), the system was being used in all federal agencies by 1965. PPBS can be considered one specific technique of the general approach known as cost-benefit analysis. Hu, Lee, Stromsdorfer, and Kaufman (1969) define cost-benefit analysis as "a procedure by which relevant economic and noneconomic criteria are applied to cost and benefit data to compare the relative merits of alternatives" (p. 20). Succinctly stated, the intent is to compare not only the costs of different alternative courses of action but also the benefits that each would produce.

This approach differs markedly from what institutions of higher education attempted to do in the past through budgetary and planning functions. As Clark and Huff (1972) point out:

> Traditionally, institutions have planned and budgeted on the basis of inputs to departments in the form of dollars, faculty, staff, physical facilities, etc. Relatively little reference was made to the outcomes of the programs those departments support. Thus, resource requests in traditional budgets have failed to link costs to program outcomes (p.5).

Since program budgeting is the most frequently adopted vehicle of cost-benefit analysis, the present description will focus primarily on this specific technique. Parden (1971) notes that a planning, programming, budgeting cycle can be conceptualized in terms of the following ten sequential steps:

1. Establish objectives and goals.
2. Develop alternative programs that will accomplish the same goal.

3. Estimate resource requirements for each alternative.
4. Estimate benefits to be gained from each program alternative.
5. Develop an operating plan by selecting from among alternatives.
6. Test the long range fiscal implication of the plan.
7. Compile the annual budget.
8. Evaluate the success with which program benefits are achieved.
9. Revise planning standards.
10. Repeat the cycle to accommodate changes in objectives, goals, available resources, and the institution's environment (from pp. 203-208).

The way in which these ten steps are put into the planning, programming, and budgeting process is described by Farmer (1970) thus:

> *Planning*—the selection or identification of overall, long range objectives of the organization and the systematic analysis of various courses of action in terms of relative costs and benefits.
>
> *Programming*—deciding on the specific course of action to be followed in carrying out planning decisions.
>
> *Budgeting*—translating planning and programming decisions into specific financial plans (p. 7).

Weathersby and Balderston (1971) view the matter similarly and add a time frame for the entire process. Their schema is presented in Table 2-1. According to Dilley (1968) the implementation of such a programmed budget format ameliorates many of the problems of traditional "line item" budgets by providing: (1) a record of accomplishments as a function of costs, (2) detailed planning for the whole institution as well as its parts, (3) planning in specific

Table 2-1. A Planning-Programming-Budgeting Schema[a]

Function	*Lead Time*	*Activity*
Planning	5 to 15 years	Articulate global objectives, costs, and benefits.
Programming	1 to 5 years	Translate global objectives into a specific short range course of action.
Budgeting	0 to 1 year	Determine specific financial, manpower, and policy plans toward goals.

[a] Adapted from Weathersby and Balderston (1971), p. 4.

written form so that it can be discussed and reviewed by all involved, and (4) planning in time perspective so that alternative courses of action can be evaluated in terms of long term capabilities.[a]

Before delving directly into a description of the types of input-output analyses that have been performed with regard to individual performance in the elementary and secondary schools, it is appropriate to mention briefly another spinoff of the basic approach that is generating much interest in educational circles.

Increasingly, attention is being centered on the development of criterion based school curricula. Also known as competency or performance based education, the new emphasis is placed on determining what specific skills are requisite to particular educational attainments (as a measure of school output), in conjunction with a specification of the inputs necessary to reach these attainments.[b] With regard to teacher education, the requirements for certification in many states have been radically altered to provide for competency based programs as a substitute for presentation of selected course work. In New York and Texas, ability to demonstrate specific competencies has now been mandated as the sole route to teacher certification (Rosner and Kay, 1973). Clearly, the attention of many has now been directed toward the actual cognitive and noncognitive abilities of students leaving educational institutions. This approach is in stark contrast to traditional reliance on the degree or diploma as a credential in itself.

While the approaches discussed in this section indicate the diversity of present and potential uses of input-output methodology, the most common use of input-output analyses (and the one pioneered by economists) has concerned the development of a tentative production function for elementary and secondary education. It is this topic that forms the basis for the next chapter.

[a] Additional information on PPBS implementation and implications can be found in Newton (1972), and Huff and Manning (1972).

[b] Much of the work on criterion based education has taken place in the context of teacher preparation programs. While a discussion of these efforts is not within the scope of this volume, additional information can be found in Schmieder (1973), Elam (1972), and Broudy (1972).

Chapter Three

Production Functions in Secondary Schools

It has been stated earlier that the educational production function relates educational inputs to educational outputs. To describe a production function therefore we need information about inputs, outputs, and the process by which inputs are transformed into outputs. This chapter focuses briefly on the underlying characteristics of outputs, inputs, and the input-output process in reference to the secondary school system.

In very general terms, it is commonly recognized that educational outputs are functions of a number of types of input. They include student characteristics, school related factors, and other community influences. The school related factors are of particular interest to economists because these are the inputs that typically can be manipulated by school administrators and hence influence resource allocation in education. The remaining inputs are also of concern and interest, and public policy can surely influence many such factors, especially over the long run.

Moreover, it has become apparent that an educational system cannot be assumed to produce a single output, such as basic skills in reading and mathematics, either to the exclusion of or entirely independently of other outputs. Even if one is not interested in other outputs, the interdependence among the outputs requires an analysis involving other outputs as well. Finally, even if one is able to identify and measure all the relevant inputs and outputs, there remains the task of describing the process by which inputs are transformed into outputs. This latter task is formidable, and very little progress has been made on this score despite the recent surge of studies on educational production.

INPUTS

Much progress has been made both in identifying and measuring educational inputs. At the secondary school level, we must distinguish between inputs provided by the schools and those externally determined. Among the school factors we may wish to further distinguish between easily manipulable factors and those not easily manipulated by the administrators. Among the nonschool factors we may wish to distinguish between those factors that affect a student directly and those affecting the student indirectly through a community's environment.

School Inputs

The identification and quantification of school related inputs is not an easy task. The school's environment includes both human and physical resources, and each of these categories is highly complex. Moreover, in attempting to evaluate the contribution of a given input to the output of a given student or class of students, it is often difficult to ascertain which portion of the input under discussion is relevant to the current investigation.

For example, if the present analysis is concerned with the educational output of students completing eleventh grade, should we evaluate teacher characteristics of those teaching eleventh grade only or should we also include other teachers in the measurement? Further, should we attach weights to the characteristics of the various teachers based upon the time they contribute to the eleventh graders (recognizing that many, if not most, are likely to teach in other grades as well)? Moreover, would average teacher characteristics be sufficient, or should one attempt to disaggregate the teaching staff into a number of components (e.g., vocational, science, language arts, etc.)?

To make things even more complicated, it has been argued that even successful measurements of such variables as teacher characteristics provide only proxies for the real inputs (Mood, 1970). For example, a variable measuring the educational preparation of teachers only indicates an average teacher attribute, not a teacher input. Its use in the production function is based on the assumption that once having such an attribute, an input into the production process is also likely to result. Thus average educational preparation is used as a proxy for the organization and quantity of knowledge that teachers attempt to transmit to students.

This, of course, is far different from the definition of inputs in ordinary production analysis, where an input is measured in real terms (such as tons of steel) and not through a proxy. One should not therefore be surprised if some of the input proxies do not appear to exert any statistical influence on the outputs.

The conclusion is not necessarily that the input is ineffective, but perhaps that the evidence does not support the contention that the proxy used is indeed a good index of the real input.

School inputs include both human and physical inputs. A comprehensive study would require an investigation of both. Among the physical inputs one could distinguish building characteristics (the technological design with respect to both instruction and ease of communication among related groups of faculty members, general condition of facilities, etc.), quantity and quality of equipment, both for vocational instruction and teaching aids (audiovisual, etc.), and supply room and other supporting physical facilities. The human inputs typically emphasized in studies of this nature include teachers, administrators, secretarial, clerical, and other auxiliary staff, counselors, and paraprofessional teaching aides. Since a large fraction of schools' budgets is spent on the teaching staff, much attention has been directed to the efficacy of teachers, and various measures reflecting their attributes have been proposed and employed.

A popular variable measuring teacher input is average teacher salaries. Although it has considerable appeal, it is lacking in many respects. An average teacher's salary is typically based on a teacher's experience and educational preparation; thus the assumption that teacher salaries are a good proxy for teacher input implies that salaries alone are a good measure of teacher productivity. It would be surprising if such an implication can be shown to be true, in light of the fact that salaries take no account of teachers' talents, enthusiasm, resourcefulness, and dedication to the profession (Cohn, 1970 and 1973).

Moreover, teaching experience could serve as both a positive and a negative input proxy; on the one hand, experience is a proxy for "on-the-job training" and "learning by doing." An experienced teacher knows the ropes, as it were, and thus can save considerable time and energy with regard to lesson preparation and discipline problems. At the same time, experience may also be a proxy for professional obsolescence and depreciation of human capital (when other variables are held constant). The effect of experience on educational production will therefore depend on the extent to which one input represented by experience is offset by the other.

What the foregoing discussion implies is the need to examine various potentially productive attributes of teachers, including educational preparation, experience, resourcefulness, talents, attitudes, and classroom practices. Even if a school is successful in recruiting a staff with excellent productive attributes, teacher productivity would be reduced to the extent that teachers are overburdened in terms of excessive teaching load and the number of subject matter assignments they are required to handle each year. In consequence, input proxies measuring the extent of teaching load and subject matter preparation should be included in the system. These variables are all the more interesting as they may be manipulated relatively easily by the school principal (Cohn, 1971).

In addition, one should not lose sight of the possibility that different class sizes might also influence teacher productivity. Other school related variables include the breadth and depth of the curriculum, the sheer size of the school, the type and extent of extracurricular activities, and the nature of and accessibility of students to the school library.

Nonschool Inputs

It is by now common knowledge that factors outside the school itself are likely to contribute substantially to a student's educational output.[a] Peer influence is one such general factor. Interest may then be focused on the general characteristics of the student body—among them parental socioeconomic levels (measured by family income, educational level of mother and father, number of books at home, etc. Race, sex, family size, and other attributes have all frequently been mentioned. In addition, general characteristics of the student environment (community indices) are alleged to affect educational outcomes. They may be measured by degree of urbanization, extent of poverty and existence of substandard housing, racial composition, average educational attainment of adults, and average personal income and wealth. The attitude of the local community toward education may be captured by such variables as the voting record on school bond issues, or tax effort, as measured by the ratio of school tax receipts to total taxable property value.

Another input that conceptually should be included in the model is the initial educational endowment of the students. Inclusion of such a variable would permit analysis of the gain in output over a given time period. Although some of the variables discussed above regarding student socioeconomic characteristics are typically correlated with initial educational endowment, they are clearly a less than ideal alternative. As Levin points out, however, the innate endowment variable "is usually omitted for lack of a reliable measure" (Levin, 1974, p. 5).

Manipulable vs. Nonmanipulable Inputs

Quite obviously, some of the aforementioned inputs are not manipulable by school or any other government officials. A good example is sex, race, and age of students. In addition, some inputs are more easily manipulable than others. For example, parental education and socioeconomic status could, in principle, be manipulated, but this cannot be accomplished by school officials, nor can it be accomplished quickly and easily by other government bodies. The conclusion of the Coleman Report and various other studies regarding the strong effect of nonschool variables on educational output has ramifications for long run social policy, but it provides little comfort to school officials who strive to increase educational output with shrinking budgets (measured in real terms). It is for this reason that this study emphasizes manipulable inputs.

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[a] For a detailed survey consult Averch et al. (1972).

Among manipulable inputs subject to control by various hierarchies in the school system, mention may be made of the following: (1) teaching load, (2) average number of subject matter assignments per teacher, (3) class size, and (4) number of curriculum units. These inputs may be manipulated to some extent by the school principal (and, of course, also by the superintendent). Given a fixed number of teaching positions, the principal can choose between a smaller class size and heavier teaching load, and also between a smaller number of curriculum units per semester and a smaller number of subject matter assignments per teacher.

Although the principal is typically constrained in his decision making process by rules requiring a ceiling on class size and/or a floor on curriculum units—as well as by collective bargaining agreements pertaining to such matters as teaching loads and assignments—there is likely to be a good deal of room remaining for maneuvering the four variables so that significant improvement in educational output may result. What we wish to emphasize here is that although some inputs could be manipulated at the school level, in the absence of information relating inputs and outputs, gains from such manipulations are not likely to be reaped (see Cohn, 1971 and 1974b). A number of other inputs may be manipulated also, especially at the district level. These include teacher experience and training (through changes in hiring policies), teacher salaries, availability of equipment, supplies, library facilities, and so forth.

OUTPUTS

The outcomes of education from the standpoint of economic analysis may be classified into two categories: consumption and investment (Schultz, 1963). The consumption aspect is related to the joy, pleasure, and similar benefits derived by students, their families, and society as a whole. The student might sometimes experience negative consumption (he or she would rather do something else), but activities such as music, sports, arts and crafts, and the like appear to contribute to a student's enjoyment of school and hence to consumption benefits. In addition, the family is relieved of responsibility toward the youngster during the school hours—a highly important consumption benefit often overlooked by

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teachers and parents alike (Weisbrod, 1962, especially pp. 116-118). Society, too, gets consumption benefits in the form of reduced crime, the enjoyment people get from observing youngsters learn, play, and behave in an orderly fashion, and perhaps even the lessened competition for jobs created by keeping job-ready youth in school for additional three to four years.

The investment component includes a variety of outputs related to the enhancement of an individual's or society's productive skills and future well being. The distinguishing characteristic here is that some of the educational outputs will not provide benefits to society until some time in the future (some will come sooner, some later). Obvious examples are the acquisition of basic mathematical and verbal skills, vocational preparation, improved health habits, inculcation of social and moral values leading to improved citizenship, or improving one's attitudes toward self, family, peers, and society.

It is much easier to specify the kinds of educational outputs than to define them in precise terms. Not only is it not unanimously agreed what attitudes toward, let us say, sex should be, but even for such outputs as increased knowledge in basic skills it is not quite clear how a student's or a school's performance can be measured. Thus we find a number of different basic skills test batteries, all purporting to measure the same output.

The question posed most frequently is not merely what the present level of skill is, but rather what improvements in basic skills have taken place over a certain time period. Furthermore, even if only the present skill level is adequate, we must contend with the "ceiling" problem. That is, it becomes successively more difficult to increase a student's score as one approaches the maximum score, so that statistical comparisons of the type described herein are likely to underestimate the ability of some schools to manipulate inputs to achieve higher skill levels (and, conversely, overestimate it for other schools).

Educational outcomes are often referred to in the educational literature as cognitive or noncognitive. This classification is especially important since few noncognitive outputs have been incorporated into educational input-output analysis to date. From an economic viewpoint, however, the distinction is of little value, as both cognitive and noncognitive aspects of the educational process provide consumption and/or investment benefits. Our attempt here is, therefore, to list as many of the relevant outputs as possible, and obtain reliable means by which such outputs may be measured.

Relevant Outputs

Basic Skills. A student's success in acquiring new mathematical or verbal skills has for long been the cornerstone of the analysis of educational performance. Many test batteries are available: the Iowa Tests of Basic Skills, the Iowa Tests of Educational Development, the Stanford Achievement Test, or the well known college entrance tests, such as the ACT and SAT. All these tests have been utilized in one or more input-output studies of education, as will be shown later.

Vocational Skills. Despite the fact that huge sums have been invested in vocational education, no systematic vocational tests of the type developed for basic skills have been used to assess the performance of vocational education. Instead, market oriented studies have been undertaken to assess the contribution of vocational education to one's employment opportunities and/or earnings (Hu, Stromsdorfer, and Lee, 1971, Corazzini, 1968, and Taussig, 1968). Since vocational development is clearly an identifiable educational goal, its exclusion from a formal model of the educational process cannot be tolerated.

Creativity. This is another dimension of school output long ignored in input-output studies. Yet some schools do attempt to foster creativity. Measures to assess the success of schools in that area should include both creative output (a measure of consumption benefits) and increasing creative potential (investment benefits).

Attitudes. Because attitudes are difficult to quantify, and because, as noted earlier, society is not unanimous about the "proper" mix of individual attitudes, it is not surprising that student attitudes have rarely entered a formalized educational input-output model.[b] Yet one of the main functions of schools (frequently cited in state constitutions) is the inculcation of "proper" attitudes. These include attitudes toward oneself, toward one's peers, family, the community, society at large, the school, and the world in which we live. One might include in this category a school's attempt to influence a student's life style, including career aspirations, health habits, and sex and family education.

Measurement of such outputs is clearly extremely difficult. It is not impossible, however. Just as tests of cognitive skills have been developed and utilized over a span of more than half a century, so too instruments can (and some have been) developed to measure attitudes. Psychologists have by now amassed an incredible amount of experience in measuring motivation, job satisfaction, and other types of attitudes, and similar effort can be directed to the measurement of attitudes that comprise educational outcomes. A later chapter provides data on a number of attitude outputs adopted in the Pennsylvania Plan.

[b] A notable exception is a recent study by Mayeske and his associates (1973b).

Other Outputs

A number of other outputs should be mentioned. For example, Burkhead et al. (1967) used the inverse of the dropout rate as an output of the secondary school system. This is perhaps mainly a consumption type of output, as some studies indicate that the investment value of dropout prevention programs is not likely to be positive (Weisbrod, 1965; Ribich, 1968, pp. 51-60). Also, the role of some schools as welfare stations should be studied, as students from poor homes receive hot meals, stay in a warm and a relatively sanitary place, receive counseling, and so forth.

In addition, a review of the literature indicates a general failure to measure students' knowledge in areas other than basic skills. It appears obvious that educational output includes knowledge gained in the humanities, the social and behavioral sciences, and the natural sciences.[c] Finally, the benefits to students and others from other activities, such as music, arts, and sports have generally been ignored. Yet such activities represent important consumption benefits, and in some cases (such as for students who receive college scholarships in athletics or who become professional athletes, musicians, or artists) also investment.

It should be noted, however, that an analysis of all such outputs as outlined in this chapter is both too cumbersome and unnecessary, for the proxies that inevitably must be chosen to represent the various outputs are likely to be intercorrelated, so that a vector of a subset of all outputs is likely to provide as much information as the entire output set and at a lesser cost. The implication of this is that whereas all outputs mentioned here should be investigated, it is not recommended that all outputs be used in every empirical study. The choice of the ideal set of outputs will depend on the relative ease with which outputs may be quantified and the degree of intercorrelation among the various outputs consistently found in other studies.

THE INPUT-OUTPUT PROCESS

The description and quantification of the inputs and outputs is necessary but not sufficient for input-output analysis. It is also necessary to specify the manner by which inputs influence outputs: or in economic terms, we need to know something about the shape of the educational production function.

Economic theory provides a number of useful theorems that guide the analyst in his attempt to specify a production function. For example, it is asserted that each factor of production should be subject to diminishing marginal returns, such that successive additions of any factor of production, when all other inputs are held constant, should result (at some point) in successively smaller increments to output.

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[c] Although these subjects were included in the Equality of Educational Opportunity Survey, analyses of the survey data largely use a composite score for all areas tested.

Considerable work has been directed toward identification and estimation of the "best" production function, based on both theoretical developments and empirical investigation of various industries. One must remember, however, that the education "industry" is far different from most other industries in scope and character, and that furthermore we are faced with the difficult problem of multiple outputs in the production process. It is therefore not too surprising to discover that few analyses of the educational sector have been patterned after the typical industry production model.

It would be worthwhile to restate the problem with the aid of mathematical notation. Let the vector of educational outputs be denoted by $\mathbf{Q}: q_1, q_2, \ldots q_n$, the vector of school related inputs by $\mathbf{X}: x_1, x_2, \ldots, x_k$, and the vector of nonschool inputs by $\mathbf{S}: s_1, s_2, \ldots, s_m$. We thus have a total of n outputs and $k + m$ inputs. The generalized educational production function is given by:

$$f(\mathrm{Q},\mathrm{X}/\mathrm{S}) = 0 \qquad (3\text{–}1)$$

That is, once the levels of the nonschool inputs are given, the determination of the expected levels of the outputs will depend on both the levels of the school inputs and the functional operator, f (which specifies the shape of the production function). If diminishing marginal returns for each productive factor are to hold, then $\partial^2 q_i / \partial x_i^2 < 0$, for all i. This condition does not hold for a linear production function, yet the vast majority of studies in educational input-output analysis specify linear functions (as does this study).[d]

A linear relationship between the X inputs and the Q outputs would be empirically valid to the extent that the curvature of the total output function is only mildly violated by employing a linear approximation. This is illustrated in Figure 3-1, in which a total output curve is drawn for one input and one output. To the extent that the range of the data is given by the arc segments AB or BC, a linear approximation would appear to provide reasonably good estimates of the true production coefficients. However, if the range of the data is given by the arc segment AC, the linear approximation will seriously distort the true relationship between the input and output. Moreover, conclusions derived from linear analysis should not be applied to input levels beyond the range of the sample observations. For use of the production coefficients for the purpose of extrapolation might result in predictions that are far off the mark (compare, for example, point C with an extrapolation of the line segment AB to C′, or point A

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[d] Mayeske and his colleagues have used the technique of "criterion scaling" to account for nonlinear relationships. See Beaton (1969), and Mayeske et al. (1972), pp. 10–11.

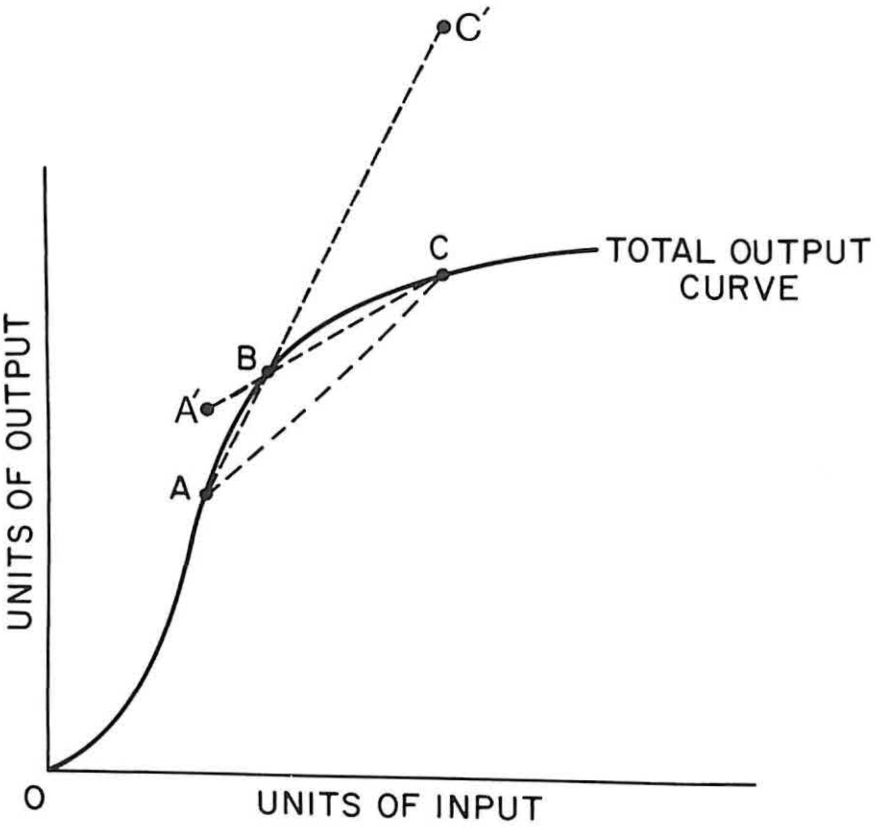

Figure 3-1. Total Product Curve and Linear Approximations

with an extrapolation of the line segment BC to A′). These conclusions about extrapolation are no less pertinent to models that employ curvilinear analysis, because the shape of the production function may be different from that assumed or inferred at unobserved input levels, and the danger of extrapolation errors remains.

If a linear model is accepted, then the general form of the *i*th production function is given by:

$$q_i = a_i + \sum_{g=1}^{n} b_{ig} q_g + \sum_{h=1}^{k} c_{ih} x_h + \sum_{j=1}^{m} d_{ij} s_j \qquad (3\text{-}2)$$

where a_i is the intercept (constant term), and the b_{ig}'s, c_{ih}'s, and d_{ij}'s are the (slope) coefficients we wish to estimate, with $b_{ii} = 0$. This equation assumes linearity in all variables, and that some of the outputs other than q_i might have coefficients different from zero (a good number of the b_{ig}'s could, of course, be equal to zero). Of particular interest are the coefficients c_{ih} which represent the marginal productivities of the school inputs, about which most of our subsequent discussion will concentrate.

Since there are n outputs, n equations of the general form (3-2) will be specified. As long as not all the b_{ig}'s are zero, it is apparent that the various equations will not be independent of each other. Thus the determination of the true effect of a given school input (e.g., x_1) on any one output (e.g., q_1) cannot be determined without finding out its effect on other outputs. For if that input (x_1) affects other outputs, which in turn have an impact on q_1, then the total effect of the input on q_1 would differ from what an isolated examination of the production function of q_1 would reveal. The n equations of the type (3-2) should therefore be considered as an interdependent system, and the coefficients in each of the equations should be estimated on the basis of techniques available for simultaneous equations (Johnston, 1972, Chapters 12 and 13).

CONCLUDING COMMENTS

Despite the numerous difficulties involved in identifying and measuring the inputs and outputs of education and in describing the input-output process, considerable work has been done in recent years in this area. As Chapter Four demonstrates, research has focused on a number of input-output frameworks in the belief that eventually some consistent results will emerge as an ultimate guideline for policy decisions.

If the ultimate goal has not yet been achieved it is not to be construed as prima facie evidence against the existence or the practical usefulness of the production function technique. Rather, it is a testimony to the overwhelming problems associated with conducting a sound production function study of elementary and secondary education. Progress is likely to be made only slowly, and then only provided that researchers do not abandon their search in the area. Chapter Four clearly shows that despite the lack of consistent results, the effort continues and has reached successively higher levels of sophistication. A review of the recent literature is therefore clearly in order.

Chapter Four

Input-Output Analysis in the Development of an Educational Production Function for Elementary and Secondary Schools

The preceding chapters have successively described the need for and state of research on educational effectiveness and presented various models of research used to assess the impact of school, nonschool, and interpersonal influences on educational outcomes. Through all of this, emphasis has been placed on the value and uses of an input-output approach to assessment in the educational arena.

No model or models are without drawbacks, conceptual or operational. Certain designs systematically (if unavoidably) disregard or distort important influences related to the eventual outcome. Others provide a more adequate framework for including all necessary and sufficient inputs, assuming all needed information is available. Commonly all such information is not available, and in fact could not as a practical matter be made available.

A compromise is thus in order. The education policy maker, and thus the educational researcher, must participate in an inherent trade-off. A decision must be made in terms of the most all-inclusive model that can be adopted in terms of the amount, type, and level of data that can reasonably be expected to be collected without in itself interfering with the ongoing instructional and support processes, the improvement of which is the sole purpose of the research.

In our view, the input-output model best accommodates itself to the situational and theoretical constraints. We have previously pointed out the difficulties in using aggregated student data when individual data would be most appropriate. The level of aggregation used in existing studies is presented in Table 4-1. Most studies clearly fall into the middle columns of the figures. More important, by observing the temporal sequence, one notes that later studies are more likely to be toward the right, and some studies have already operated at the individual student level of analysis. Obviously, the state of the art is making

Table 4–1. Major Input-Output Studies by Primary Level of Data Aggregation

School District, System, or Comparable Unit	*Individual School*	*Individual School, with some–but NOT ALL–Variables at Individual Student Level*	*Individual Student Variables at all Major Aspects of Analysis*
Benson et al. (1965)	Mollenkpf & Melville (1956)	Coleman et al. (1966)	Hanushek (1970)
Cohn (1968)	Thomas (1962)	Bowles (1969)	Mayeske et al. (1973a)
Raymond (1968)	Burkhead et al. (1967)	Levin (1970)	Mayeske et al. (1973b)
Keisling (1969, 1970)	Hanushek (1968)	Michelson (1970)	Summers and Wolfe (1975)
	Katzman (1968)	Guthrie et al. (1970)	
	Fox (1969)	Mayeske et al. (1972)	

individual student analysis more possible, and the theoretical problems are becoming less difficult.

In terms of former operational difficulties, similar improvement is being made through use of more sophisticated statistical management. Method of statistical manipulation is shown in Table 4-2. That increasing numbers of studies are utilizing two stage least squares (TSLS) in simultaneous-equation production functions serves to lessen the bias associated with the ordinary least squares (OLS) method.

There still must be some concern with the facts that (1) standardized test scores are not satisfactory proxies for actual competencies, and (2) noncognitive (i.e., affective) inputs and outputs have for the most part been totally ignored. However, it must be made clear that these are not problems associated with the input-output model per se; rather, these are difficulties inherent in the types of data and institutional characteristics the educational researcher confronts, and progress to overcome these difficulties will perforce be very slow.

With these caveats in mind and with an understanding of what the public is demanding under the general rubric of "accountability," the input-output model holds out the best hope of making a positive contribution to assessment of educational effectiveness. The remainder of this chapter thus proceeds to discuss existing studies of input-output in the public schools. Studies are discussed in chronological order, for the later studies are more sophisticated and build on past research successes and failures. A thread can thus be discerned through the progress which has been made.

Such an arrangement of studies allows the interested reader to draw comparisons with other similarly organized compendia of related studies available elsewhere.[a] However, the stress in this synthesis is placed upon studies utilizing production functions based on simultaneous equation systems. It should be noted that no attempt is made here to provide an exhaustive review of all educational input-output literature; yet we believe that the following survey encompasses most of the major works in this area.

THE INPUT-OUTPUT STUDIES: A SURVEY

This section provides basic information about a number of input-output studies reported in the professional literature from 1956 to the present. In a sense, input-output analysis is not new; yet use of the term itself and interest in what it means have increased markedly in recent years. Studies discussed in this section are summarized in Table 4-3.

It is generally recognized that the first large scale input-output study, and one

[a] See, for example, Heim (1972, 1973); Averch, et al. (1972); and Guthrie (1970).

Table 4–2. Major Input-Output Studies by Primary Method of Analysis Utilized

Multiple Regression			
Single-Equation (OLS)	*Simultaneous-Equations (TSLS)*	*Simple Correlation Techniques*	*Other*
Thomas (1962)	Fox (1969)	Mollenkpf & Melville (1956)	[Factor analysis]
Benson et al. (1965)	Levin (1970)	Guthrie et al. (1971)	Keisling (1969, 1970)
Burkhead et al. (1967)	Michelson (1970)		[Multiple correlation]
Hanushek (1968)	Boardman et al. (1973)		Coleman et al. (1966)
Cohn (1968)			[Factor analysis, criterion scaling, and commonality analysis]
Katzman (1968)			Mayeske et al. (1972, 1973a, 1973b)
Raymond (1968)			
Bowles (1969)			
Hanushek (1970)			
Tuckman (1971)			
Summers and Wolfe (1975)			

Table 4–3. Summary Chart of Effectiveness Studies on School Service Components

Study Author(s)	*Description of Sample*	*Measure of Pupil Performance (School Output)*	*Measure(s) of Effective School Service Component(s) (School Input)*
1. Mollenkopf and Melville (1956)	U.S., 17,000 9th (in 100 schools) and 12th (in 106 schools) grade, male and female	Aptitude and achievement tests	1. Number of special staff 2. Class size 3. Pupil-teacher ratio 4. Instructional expenditures
2. Goodman (1959)	New York, 70,000 7th and 11th grade, male and female in 102 school districts	Achievement test	1. Number of special staff 2. Instructional expenditures 3. Teachers' experience 4. "Classroom atmosphere"
3. Thomas (1962)	Project TALENT sample (national) 10th and 12th grade, male and female	Achievement test	1. Teachers' salaries 2. Teachers' experience 3. Number of library books
4. Green et al. (1964)	Virginia (Primarily Negro) Secondary students	Stanford Achievement test	1. Aggregate measure of entire instructional program
5. Benson et al. (1965)	California 5th grade, 249 school districts	Reading achievement test	1. Teachers' salaries 2. Administrators' salaries 3. Instructional expenditures
6. Kiesling (1969)	New York, 70,000 7th and 11th grade male and female in 102 school districts	Achievement test	1. Expenditure per pupil (negative) 2. Student/teacher ratio
7. Coleman Report (1966)	U.S. Sample Equality of Education Opportunity Survey (EEOS)	Verbal ability test	1. Teachers' verbal ability
8. Burkhead et al. (1967)	90,000 Chicago high school students. 19,000 Atlanta high school students in 22 schools and 180 small community high schools	Aptitude and achievement tests and school holding power	1. Age of building 2. Teachers' experience 3. Teacher turnover 4. Teachers' salary
9. Cohn (1968)	Iowa high school students in 377 school districts	Gain in achievement test (ITED)	1. Teachers' salary 2. Number of instructional assignments per teacher 3. College hours per teaching assignment (negative)
10. Raymond (1968)	W. Virginia, 5,000 high school students	Freshman year (college) GPA and achievement test scores	1. Teachers' salary

Table 4–3 continued

Study Author(s)	*Description of Sample*	*Measure of Pupil Performance (School Output)*	*Measure(s) of Effective School Service Component(s) (School Input)*
11. Katzman (1968)	Elementary school students in 56 Boston schools	School attendance, school holding power, reading achievement, special school entrance examination	1. Pupils per classroom 2. Student-staff ratio 3. Attendance district enrollment 4. Teachers' employment status 5. Teachers' degree level 6. Teachers' experience 7. Teacher turnover ratio
12. Bowles (1969)	U.S. 12th grade Negro males (EEOS)	Mathematics and reading achievement test and a test of general academic ability	1. Class size 2. Ability grouping 3. Level of teacher training 4. Age of school building 5. Expenditures per pupil
13. Bowles (1970)	U.S. 12th grade Negro males (EEOS)	Verbal ability test	1. Teachers' verbal ability 2. Science laboratory facilities 3. Length of school year
14. Bowles and Levin (1968b)	12th grade Negro students and 12th grade white students (EEOS)	Verbal ability test scores	1. Teachers' verbal ability 2. Teachers' salary
15. Hanushek (1968)	6th grade white students in 471 schools and 6th grade Negro students in 242 schools	Verbal ability test	1. Teachers' verbal ability 2. Teachers' experience
16. Fox (1969)	39 Chicago schools	Reading ability attrition	1. Building utilization 2. Man years of teacher/ support staff devoted 3. Student employment 4. Specific vocational courses
17. Levin (1970)	Equality of Educational Opportunity survey (EEOS) U.S. sample	Verbal ability student/parent attitudes, grade aspirations	1. Teacher experience
18. Michelson (1970)	EEOS U.S. sample	Verbal ability student/parent attitudes. Grade aspirations, reading ability, math ability	(for whites) 1. Teacher verbal ability 2. Teacher experience (for blacks) None reported
19. Guthrie et al. (1971)	5,284 6th grade students in Michigan	Reading ability, mathematics understanding,	1. School site size 2. Building age 3. % classrooms makeshift

Table 4-3 continued

Study Author(s)	Description of Sample	Measure of Pupil Performance (School Output)	Measure(s) of Effective School Service Component(s) (School Input)
		verbal facility	4. Library volumes 5. Textbook supply 6. Teachers' verbal ability 7. Teachers' experience 8. Teachers' job satisfaction 9. School size (enrollment) 10. Classrooms per 1,000 students 11. % of students transferring
20. Tuckman (1971)	Current Population Survey Sample, 1001 senior high schools	Percent of students completing high school, percent of students continuing education	1. Teachers with ten years experience 2. Master's degree (negative in some equations)
21. Mayeske et al. (1972, 1973a, 1973b)	EEOS U.S. sample	Expectation for excellence, attitude toward life, educational plans and desires, study habits, achievement grade, percent of 12th grade graduates going on to college (by race), percent of 12th grade graduates going on to vocational training, percent of 10th grade boys who drop out of school	1. Teaching conditions 2. Teacher race 3. Teachers' vocabulary score
22. Boardman et al. (1973)	Over 16,000 students in a subsample of EEOS U.S. sample	Verbal achievement, nonverbal achievement, reading achievement, general information achievement	1. Teachers vocabulary score 2. Teacher/pupil ratio 3. Teacher experience 4. Number of teachers leaving 5. Teachers' perception of problems with administration 6. School policy of administering tests 7. School facilities 8. Problems in school
23. Summers and Wolfe (1975)	1,896 students in Philadelphia elementary, junior high, and senior high schools	Two- or three-year gain in reading achievement scores	1. Class size 2. School size 3. Teacher experience 4. Quality of teachers' college

Source: Updated, corrected and adapted from Guthrie (1970), pp. 47–48.

from which many later studies have profited, was undertaken for the Educational Testing Service by William G. Mollenkopf and S. Donald Melville (1956). The researchers selected 9,600 ninth grade students from 100 public schools and 8,357 twelfth grade students from 106 public schools; the schools were selected from across the country. From answers to questionnaires administered to school principals, a list of 34 independent variables–including school, non-school, and peer influences–was constructed. These inputs (independent variables) were compared with a test specially designed by Educational Testing Service as the output (dependent variable).[b]

Simple (Pearson) correlation techniques were used in this study to relate inputs to the specified components of output (vocabularly score, math score, science score, etc.).[c] Of the school factors only one–library and supply expenditures–was consistently correlated with student achievement. And this variable may have been serving as an inadvertent proxy for some other school, non-school, or peer group variable. Other variables of some influence include number of special school personnel, class size, and student-teacher ratio.

Following the work of Mollenkopf and Melville, the State of New York instituted a study of some 70,000 seventh and eleventh graders in the state's public schools. As with the study before it, Samuel M. Goodman (1959) attempted, (in what is popularly known as the New York Quality Measurement Project) to control as best he could for the effects of parents' socioeconomic status. As with some studies that were to follow his, Goodman found some distinct influence from a not too clearly specified variable he called "classroom atmosphere."[d] However, very much unlike certain succeeding studies, Goodman found the variable of teacher experience to have a potent *positive* effect on student achievement. Others, who will be discussed later, have also seen teacher experience or teacher training variables to significantly affect student output; however, the effect has not been as consistent as would be intuitively desirable.

In 1962 James Alan Thomas (1962) conducted the first major study to rely on regression techniques as the primary means of statistical analysis. Using input and output data generated for Project Talent in over 200 schools in a national sample, Thomas found, from a list of 27 input variables, the following three school variables of particular importance: starting teacher salaries, teacher experience, and number of books in the school library. A short time later Benson

[b] For clarity here, the input is pointed out to be the independent variable, and output the dependent. This is assumed in all the descriptions that follow and the notation is thus simplified.

[c] The seven individual test scores were eventually clustered into verbal and quantitative indices.

[d] Others have alluded to "environmental press," "empathic understanding," "nonthreatening atmosphere," and so forth.

and his associates (1965) conducted a study of California school effectiveness for a state senate fact-finding committee. After controlling for student background factors, they found a significant positive relationship between teacher salaries and student achievement.

Perhaps the largest, most comprehensive, and most hotly debated study was published in 1966. Directed by James S. Coleman and his associates (1966), a study entitled *Equality of Educational Opportunity* attempted to determine the school and nonschool factors related to the achievement of over 600,000 students from coast to coast. Popularly known as the "Coleman Report," the study found very little association between school factors (taken singly or collectively) in comparison to nonschool factors. Of the school factors, teachers' verbal ability seemed to be of most importance.

The Coleman report has been criticized along three basic axes.[e] First, there is uncertainty as to whether the measurements used are sufficient for the task involved. Second, the handling of the data is thought by some to have been less than precise. Perhaps most damning, however, is the fact that many contend the manner by which the regression technique was used in effect stacked the cards against any strong showing by school factors.

Basically, this latter argument is that stepwise multiple regression requires the statistical assumption of independence of variables. Where such independence is not present (i.e., multicollinearity is present), the first variables to be entered (in this case nonschool factors) will appear most potent. In fact, the nonschool and school factors may be so nested within each other that their effects cannot be so arbitrarily separated. This criticism has been expounded most persuasively by Bowles and Levin (1968a, 1968b).

Nonetheless, the Coleman Report stands as a benchmark for a number of reasons. More than any other study, it provided an impetus for theorists of all orientations to become more involved in what had previously been a very specialized and obscure branch of educational research–input-output analysis. Because of its indictment of school effectiveness (whether that indictment was well founded or not) it also stimulated greater interest in other areas of school research and functioning.

By size of sample, number of variables, number of associates, wideness of distribution, and amount of data, Coleman's work is also distinguished from most other studies past and future. The study used data from and about 645,000 individual students well distributed by type and location of school. Ninety-three separate input variables were delineated. The outcome measure consisted of ten scores, including uniquely a measure of nonverbal skill. To this day, researchers continue to fill professional journals with research based on the Coleman data base, albeit alternatively supporting and debunking Coleman's conclusions. By any standard, the Coleman work is destined to be considered a classic in the literature of educational assessment.

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[e] In addition to the criticisms made by Bowles and Levin (1968a, 1968b), see also a brief description of the controversy in Mood (1973).

As another aspect of the New York Quality Measurement Project, Herbert Keisling (1967) assessed input and output in varying kinds of school districts in New York.[f] Keisling looked at large and small, urban and rural school systems. Keisling found significant relationships between the cognitive output measures and student-teacher ratio and expenditures for books and supplies. However it must be stressed that the relationships were negative and the variables had large coefficients. Keisling reports that none of the other variables was uniformly important.

The research team of Jesse Burkhead, Thomas G. Fox, and John W. Holland (1967) were able to conduct a unified study of 39 Chicago schools, 22 Atlanta schools, and a subsample of 177 schools from the original Project TALENT sample. Although the independent and dependent variables were not identical in all three substudies, there was sufficient similarity to compare like items. In Chicago and Atlanta, family income was positively related to reading and verbal skills respectively. Teacher experience and teacher salary, respectively, were both associated with positive outcomes. Using the Project TALENT sample, family income, teacher experience, and salary were significant positive variables.

Martin T. Katzman (1968) examined data from 56 Boston elementary schools. In addition to the typical input and output variables, Katzman also looked at student cultural advantage, degree of school overcrowding, attendance rate, school attrition, and size of school district. Results of overcrowding were not consistent, but economies of scale did appear in larger attendance area in terms of incremental reading ability and lessening of attrition. Teacher experience variables seemed inconclusive, although level of teachers' degrees was generally positive.

Also looking at possible economies of scale in education was one of the authors' study (Cohn, 1968) of 377 Iowa high schools, the overwhelming majority of which constituted the only public secondary schools in their districts. In addition to determinging the most efficient size for school districts, a significant negative relationship was found between the output measure (increment in scores on the Iowa Tests of Educational Development), and two inputs: (1) number of teacher's college credit hours, and (2) number of discrete teaching assignments per teacher. A significant positive relation was found between output and median teacher salary.

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[f] The Keisling work was originally reported in a 1965 unpublished doctoral dissertation. Variations on the study appear in Keisling (1969). A somewhat different New York sample is analyzed in Keisling (1970). The results of all these efforts are discussed here collectively.

Richard Raymond (1968) in an ex post facto study examined the precollege educational backgrounds of in-state students who entered West Virginia University. Because of the time frame involved, Raymond used a very different set of criterion measures. He used college freshman grades along with composite scores on the American College Test (ACT) as the output measure. By county of precollege attendance, he then compared the output with school inputs. He derived nonschool variables from 1960 census data for the various West Virginia counties. Of the school components, he found teacher salary positively significant, with the student's elementary school teacher salary being the most potent predicator.

In one of the earliest studies to look specifically at whether school and nonschool inputs might have a differential effect on blacks and whites, Hanushek (1968; see also Hanushek, 1972) examined the records of black and white sixth grade students in the northeastern and upper midwestern areas of the country. Hanushek's sample intentionally included students in predominantly white as well as predominantly black school situations. In this research, separate regressions were run for the black and the white samples. The data used were all drawn from the original Coleman data files for the geographical areas being studied.

Hanushek looked at a wide array of home and school variables including parents' education, preschool exposure, racial mix, and school location. Teacher experience and teacher verbal ability were also measured. Hanushek found that basically the same input variables were operative for both black and white students. He found the two teacher variables to be significantly positive for both black and white.

Samuel Bowles (1969) has also attempted to build a true educational production function using Project TALENT and Coleman Report data. The sample for this research consisted of black students who participated in the two national samples in either 1960 or 1965. While a great deal of emphasis was placed on nonschool variables, negative school components included large class size and age of facilities. Elsewhere, Bowles (1970) also stresses the importance of facilities in general, and science facilities in particular.

Bowles, along with Henry M. Levin, had been among the most vocal and persistent of critics of the methodology and conclusions of the Coleman Report, as was pointed out earlier in this chapter. Their basic disagreement has appeared in a number of places (Bowles and Levin, 1968a, 1968b; and Bowles, 1970). In 1968 the two authors (Bowles and Levin, 1968b) reported results of a reanalysis of the Coleman data and found a significant positive influence of teacher verbal ability on both black and white student performance. Again, they also found teacher salaries and availability of adequate facilities (particularly science) to be positively related to achievement.

Thomas G. Fox, who earlier had collaborated with Burkhead and Holland (Burkhead, Fox, and Holland, 1967), reported again on an analysis of his 39 Chicago schools in a separate paper (Fox, 1969). Using two of his original output measures–reading scores and school attrition rate–he constructed a somewhat different set of school input measures, including school building utilization rate, capacity of building cross-footed by age, book expenditures, man years of teacher and support staff time committed to the school and student time in specific vocational courses, and the employment status of students. These inputs reflected variables that had not been in the forefront of research on educational effectiveness. While book expenditures and building capacity by age were not significant, the other elements were found to be variously positive. The research shed some new light on additional variables of potential influence. Moreover, Fox's study presents the first simultaneous-equation model of educational production.

In a second study by Eric Hanushek (1970), 1,000 students in a single school district in California are studied. This research is distinguished from all those previously discussed because the entire analysis proceeded from data at the individual student level of aggregation. In order to carry the procedure forward, it was necessary for Hanushek to delete all cases in which any information was missing. For example, if a student moved into or out of the system, and characteristics of all previous and current teachers were not available, the case was removed. This requirement dropped the sample size from nearly 2,500 to just over 1,000 subjects.

Since the most visible minority in the school system was Mexican-Americans, Hanushek compared these students with whites. He stratified the two groups into four subgroups depending on whether the student's father was in a manual or nonmanual occupation. In terms of school factors, it is interesting to note that teacher experience and teacher education level were found *not* to be significantly related to the output measure (Scholastic Aptitude Test scores) for any of the groups. Since this study is the first to operate at the individual student level, the lack of relationship of the output to the two most commonly used school input factors must cause a serious reevaluation of those studies which have shown these variables to be positive and significant.

Henry M. Levin (1970) presents another study that attempted to use the Coleman data pool while avoiding some of the methodological problems that plagued the original Coleman analysis. As the output measures Levin specified, in addition to verbal score, student and parent attitudes, and student grade aspirations. In the two stage least squares (TSLS) regressions, only teacher experience was positive and significant in terms of the verbal ability output.[g]

Appearing in the same volume in which the above Levin study appeared is a report by Stephan Michelson (1970), also using the Coleman data. Michelson used the same dependent variables as Levin, but added test scores for reading and mathematics as well as verbal ability. Independent variables were similar to Levin's. Stratifying the sample on race, Michelson used both single and simultaneous equation systems. For whites, some school inputs were consistently positive using the TSLS approach for verbal ability. These include teacher verbal ability and experience. Results are less consistent for other outputs. No significant relationships are reported for blacks.

Another view of possible reinterpretation of the Coleman conclusions is presented in a study by James W. Guthrie and his associates (1971). Guthrie's team looked at the Coleman data for the state of Michigan. While the sample contained both blacks and whites, the group was not stratified by race, but rather by socioeconomic status regardless of race. The authors report a series of school inputs positively related to achievement under the general categories of facilities, materials, teacher characteristics, and peer environment. Significant teacher variables included verbal ability, experience, and job satisfaction.

Another study appearing in the same year (Tuckman, 1971) made use of a Current Population Survey of 10,700 elementary and secondary schools. Tuckman chose a subsample of 1,001 senior high schools. For that sample, data were available on two inputs: percentage of teachers with ten or more years of experience, and percentage of teachers holding at least a master's degree. Additional inputs included education of parents, sex, race, region, and the proportion of students who were behind in grade. On the output side, five measures were used: percentage of students completing high school, percentage continuing to any higher education, percentage attending a four-year college, percentage attending a two-year college, and percentage going on to other educational institutions.

The novelty of the Tuckman study is his attempt to study the effect of interaction between school and nonschool variables. His analysis indicates that the output effects of the school inputs, based on the typical linear regression analysis, differ from those obtained through the interactive model. Since very little is known about such interactive influences, studies of this nature are clearly desirable. However, when studies involve a large number of variables—as do most of the large surveys described herein—the number of interactive combinations becomes almost astronomical, and a meaningful analysis of interaction is almost entirely out of question.

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[g] Levin provides additional results in a recent paper (Levin, 1974) in which he argues that failure to incorporate in educational production function analyses all the relevant outputs might seriously distort the production coefficients and lead to erroneous policy implications.

After a span of some years, another work has caught the public eye and galvanized public opinion. Perhaps destined to be as controversial as the Coleman Report, the work by Jencks and his associates (1972) sees the appropriate outcome of schooling not as demonstrated student achievement, but as equality of opportunity. In this regard they find the school deficient.

> [It is our contention] that differences between schools have rather trivial long term effects, and that eliminating differences between schools would do almost nothing to make adults more nearly equal. Even eliminating differences in the amount of schooling people get would do relatively little to make adults more nearly equal. If this is true, schools ought to be judged largely by their short term effects. This does not, in our view, weaken the case for distributing school resources and opportunities equally. But it means that this case is no different from the case for making the distribution of public parks, trash collection, or other public services equal (pp. 16–17).

Jencks contends that the main value of the school is its immediate effects as a milieu. He finds this to be no small task in itself, although others continue to suggest the need for a more long term educational output to society.

Considerable work has been underway for some years in the U.S. Office of Education to reanalyze the massive data supplied by the Equality of Educational Opportunity Survey (EEOS). The Coleman Report was the first published document regarding the Survey, but certainly not the last, necessarily, nor even the most significant. As Mood (1973) points out, the reanalyses by Mayeske and his colleagues "have viewed the survey information far more deeply and expertly than was possible in the limited time available to prepare the original [Coleman] report. Together they represent a giant step forward in understanding some of the most fundamental aspects of education in our public schools" (p. iii).

The three Mayeske reports (named after their major author, George W. Mayeske) were published during 1972 and 1973, although working papers providing much of the analyses had been made available in more limited quantities as early as 1969. The Mayeske reports may be distinguished from the Coleman study in two main respects: (1) the Mayeske reports study both schools and pupils respectively as the unit of analysis, and (2) the Mayeske reports have used more sophisticated statistical techniques in their analysis.

The first Mayeske report (1972) is focused on the schools as a unit of analysis. Within-school variations are ignored. The main technique for analysis is termed "commonality analysis," which is used to divide the squared multiple correlation coefficient into portions of the variance uniquely explained by each variable (or sets of variables) in a multiple regression equation and the proportion of variance commonly explained by two or more (sets of) variables. For example, if the outcome (dependent variable) is designated by X, school factors by S and nonschool factors by B (independent variables), then the analysis provides an equation such as:

$$R^2(S,B) = U(S) + C(S,B) + U(B)$$

where $R^2(S,B)$ is the squared multiple correlation coefficient, derived by regressing X on S and B, $U(S)$ and $U(B)$ are, respectively, the unique variances attributed to S and B, whereas $C(S,B)$ is the residual variance of X explained by S and B together (exclusive of any error term).

The study employs factor analysis to generate indices of school and nonschool variables. The latter were then studied in relation to a number of school outcomes, including achievement, students' expectations for excellence, attitude on life, educational desires and plans, and study habits. The major finding was that, on the whole, the unique contribution of school factors to explaining variations in outcomes was extremely small. At the same time, the common variance may be quite large, indicating the likelihood of strong interactive effect of the school and nonschool variables (confirming Tuckman's analysis described above).

A number of other results deserve mention here:

1. A high correlation was found for schools among the various outcomes. "In other words, favorable performances tend to facilitate and reinforce one another" (p. 111).
2. Among school variables, those related to a school's personnel were shown to have greatest effect on outcomes, both in terms of the unique variance explained and the size of the commonality factor.
3. Expenditures, school facilities, and pupil programs and policies are generally unimportant, measured both by the unique and common variance explained.
4. "Teacher attributes highly related to school outcomes were those reflecting a teacher's experiences in racially imbalanced educational settings" (p. 113). The authors cite the typical attendance of nonwhite teachers in predominantly nonwhite institutions (which are deemed less desirable) as a possible cause for lower output by students exposed to such teachers.

A major general conclusion of the report echoes conclusions reached by Coleman and his associates as well as by Jencks and other critics of the educational system:

> For both students and teachers, the American educational system reflects the structure of American society. It, therefore, tends to perpetuate and even further increase the differential learning experiences that students bring to the educational setting by virtue of their birth (p. 113).

The second Mayeske report (1973a) focused on student achievement. Two of the main findings should be mentioned.

1. "There were indications that the color-caste aspects of the social structure, as represented by Racial-Ethnic Group Membership, had a greater impact on achievement in the south, and would consequently be more difficult to overcome by means of educationally related childrearing activities" (p. 147).
2. The unique contribution of school factors to achievement was found to be quite low (4 percent). The effect of the school variables was thus seen to operate mainly through their interaction with variables representing background (socioeconomic status, family structure, racial-ethnic group membership) and family process (expectations, aspirations, beliefs regarding life, stimulation and support).

The third Mayeske report (1973b) is concerned with an explanation of variance in students' attitudes toward life. Most of the material in the report deals with nonschool factors, so that the conclusions, while quite interesting, are not directly relevant to this volume. However, the authors conclude that a set of school inputs consisting of five teaching staff attributes did not show any independent influence on attitudes, but that the role of these variables was "completely confounded with that of the five student body variables" employed by the authors (p. 84). It is also noted that the association between school variables and attitudes was greater in the south than in the north; and finally, that there is once more considerable commonality with socioeconomic status, home background, family process, and achievement.

Another study was presented during the December 1973 meeting of the American Statistical Association in New York City (Boardman et al., 1973). The authors of the study report on the results of a simultaneous-equation model, where the endogenous (dependent) variables are various achievement measures obtained by the EEO Survey. They include verbal, nonverbal, mathematics, reading, and general information achievement. The set of explanatory variables include a variety of peer, environmental, and school related variables.

It is not clear why the authors chose the particular specification of the structural equations; further, the paper is very concise, so that it is quite difficult to evaluate the results very closely. Nevertheless, the study provides a number of interesting conclusions with regard to the impact of school variables. The first, and most important, significant variable is the average teachers' verbal score. The results here confirm previous results by Levin (1970), Michelson (1970), and Bowles (1970). Interestingly, the teacher-pupil ratio is "positively and significantly associated with each of the various measures of achievement" (p. 64), a finding that makes a great deal of sense yet one that, to date, most studies have failed to support.

Another significant school outcome is experience. The authors used a quadratic specification for that variable, indicating that the first few years of experience are negatively associated with achievement, but that as more experience is gained, the relation becomes positive. This is in contrast to the popular belief that experience is positively related to productivity during the first few years, after which the effect becomes zero or even negative.

A fourth significant factor is the number of teachers leaving. The positive correlation with verbal, nonverbal, and reading achievement may be explained by a process of "natural selection" whereby "dedicated teachers tend to be the ones who remain on the job . . . while those who really were not interested in this profession drop out" (p. 65). Also, "the perception on the part of teachers of the lack of effective administrative leadership is positively related to all measures of achievement" (p. 65). The authors explain this surprising result as follows: "Since the mean of this variable is low, one might speculate that only the better and more perceptive teachers are able to recognize such problems and these teachers perform well in any event" (p. 65).

It was also found that achievement tends to be higher in schools in which the administration of IQ and achievement tests is a matter of school policy. The authors do not elaborate, but it just might be that when such tests are administered year after year, and when schools pay attention to such results, teachers and pupils gain a certain degree of expertise in answering the questions (for students) and coaching students on the exam materials (for teachers). In consequence, this variable might be more appropriately considered as a control device rather than as a school factor.

Two other measures significantly related to achievement are school facilities and existence of problems in the school. As expected (though typically not found to be significant in other studies), the coefficient of facilities is positive, whereas the coefficient for the problems in schools variable is negative.

It should also be mentioned that factor analysis conducted by the authors indicates that all the achievement measures describe essentially the same characteristic, so that a single-equation analysis based upon only one of the measures, or an index of the five measures (as was done by Mayeske et al., 1972), would probably result in similar conclusions. However, the case for simultaneous-equation analysis is not seriously challenged by this finding, as the study was concerned exclusively with cognitive achievement, leaving aside attitudes and other outputs.

Of considerable interest, finally, is the recently published study of Philadelphia public schools by Summers and Wolfe (1975). Like one of Hanushek's studies, this one too attempted to identify school resources, especially teachers, with the students who are directly affected by such resources. In addition, the Philadelphia study employed a longitudinal measure of output–growth in achievement scores over a period of two years for junior high school students and three years each for elementary and senior high school students. Another important characteristic of the study is its endeavor to study the effect of school resources on various student groups–disaggregated by race, sex, ability, and other variables.

The results of the study indicate that some school factors are significant, including class and school size, teacher experience, and quality of degree granting institutions from which teachers graduate. Interestingly enough, these factors do not affect all students in a like manner: for example, class size appears to have an effect on elementary and senior high schools but not on junior high schools. The authors conclude that:

> In short, some school inputs can heighten student achievement: classes over certain sizes reduce learning; smaller elementary and senior high schools increase it. Net output may be increased by targeting teacher experience and higher rated college background to the appropriate students. Moreover, some of these school inputs can help offset the initial learning handicaps of race, income, and capability (p. 14).

Additional analysis indicates that the student mix–both in terms of racial composition and ability levels–is likely to affect learning in some cases. This, once again, implies a role for school management in identifying the appropriate mixes for increasing output gains. The authors also advocate structuring teachers' salaries on the basis of the teachers' productive characteristics, a suggestion proposed by one of the present authors on several occasions (Cohn, 1970; 1972, pp. 293-297; and 1973).

WHERE DO WE STAND NOW?

The lack of consistent results displayed in the preceding section should not surprise anyone. Only in recent years has educational research begun to receive the attention it deserves, and even more recently has the development of an educational production function come into its own. It may therefore be unrealistic to expect uniform results across such idiosyncratic and situational conditions as exist in American education at this point.

Nonetheless, it is unsettling to see the variation in results of input-output analyses as they have been reported in this chapter and summarized above in Table 4-3. While some school components, such as teacher experience, salary, and facilities have been shown to be significant positive influences in a number of places and at a number of times, not all studies find this to be so.

Averch and his associates are forced to conclude the following after reviewing existing studies:

> *Research has not identified a variant of the existing system that is consistently related to students' educational outcomes.*
>
> The term "a variant of the existing system" is used to describe the broad range of alternative educational practices that have been reviewed above. We specifically include changes in school resources, processes, organizations, and aggregate levels of funding.
>
> We must emphasize that we are not suggesting that nothing makes a difference, or that nothing "works." Rather, we are saying that research has found nothing that *consistently* and *unambiguously* makes a difference in students' outcomes. The literature contains numerous examples of educational practices that seem to have significantly affected students' outcomes.
>
> The problem is that there are invariably other studies, similar in approach and method, that find the same educational practice to be ineffective. And we have no clear idea of why a practice that seems to be effective in one case is apparently ineffective in another.
>
> We must also emphasize that we are not saying that school does not affect student outcomes. We have little knowledge of what student outcomes would be were students not to attend school at all. Educational research focuses on variants of the existing system and tells us nothing about where we might be without the system at all (pp. 154–155).[h]

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[h] There exists some evidence on this score. A study by Green et al. (1964) compared test performances by children whose schooling was interrupted for some years with performances by children from similar socioeconomic and locational backgrounds. The results clearly showed the importance of school: "It was found that the children whose schooling had been interrupted exhibited severe educational retardation, particularly on tests more closely related to school curriculums such as spelling and arithmetic. On an intelligence test the scores of these children were 15 to 30 points lower than those children in the adjacent county who had continued in school" (Mayeske et al., 1972, p. 113).

The answer lies not in giving up promising lines of research, but rather in refining measures of cognitive ability, finding ways to measure noncognitive functioning more adequately, better data collection, and more sophisticated data manipulation and analysis.

In a comprehensive synthesis of available studies of educational effectiveness undertaken for the New York State Education Department, Heim (1972) was able to present a slightly less ambiguous total view. Since most of the existing studies dealt with cognitive outputs, the preponderance of Heim's attention was upon such outcomes. He was particularly interested in those inputs that are amenable to policy manipulation, rather than those personal and demographic variables that cannot be changed by, or are not under the control of educational policy makers.

With this frame of reference in mind he indicated the "box scores" of those policy manipulable inputs that have been tested against cognitive outputs. Heim pointed out that five variables have been studied frequently, namely: (1) teacher degree status, (2) teacher experience, (3) interaction of noncognitive inputs and cognitive outputs, (4) class size (or student-teacher ratio), and (5) availability of special support staff.

Collapsed here into a single portrait, Heim paints the following in wide brush strokes:

> In 83 percent of the studies reviewed, it was found that . . . the higher the average level of teacher education in the school, the more impressive was student performance. . . . Teacher experience is also commonly thought to influence student performance. However, the evidence is substantially less conclusive. . . . In the 23 studies reviewed, teacher experience was found to be significantly related to student performance only 57 percent of the time. . . . Persuasive evidence was reviewed which indicates that, in part, student achievement in the intellectual skills area is related to the level of a student's development in the noncognitive domain. . . . There seems to be little evidence to suggest that, within fairly broad limits class size (or its most often used proxy, teacher-pupil ratio) has any general effect upon cognitive or noncognitive school outputs. . . . Overall, the amount of special staff per pupil was found to have a significant effect on student achievement in fewer than half of the studies in which its effect was tested (pp. 98-102).[i]

Again, the reader is cautioned not to assume that these variables are inoperative generally. It is rather stated that on the whole, only one out of five commonly tested school components is measured and shows positive impact consistently across different students in different settings.

[i] See also Heim (1973).

Educational psychologists would readily point out that human development and learning are hypothetical constructs par excellence: they cannot be measured directly, but can only be inferred from a change in performance over time. A person in isolation would change over time through the sheer force of physical maturation. When one compounds complexity of the process by replacing isolation with the effects of socialization, physical and social deprivation, and a host of other potential factors, the relationship among inputs and outputs can become quite tenuous. The dilemma is exascerbated by the need to make comparisons not only of a given individual over time, but of different individuals with different hereditary and environmental interfaces in terms of a process that typically consumes not fewer than twelve calendar years, and commonly longer.

While the timid might be given pause by the rich diversity of the human condition, drawing back from the effort is destined to only delay its solution. The solution is neither as simplistic as many would have hoped nor as insoluble as others would suggest. What is needed is the willingness to take small and tentative stpes, to consolidate knowledge of past successes and failures, and to continually refine both the instruments and the processes. It is this challenge toward which the present volume is directed.

CONCLUDING COMMENTS

The materials provided in this and the preceding chapters establish the basic framework for input-output analysis in secondary education. In the following chapters our attention is focused on an empirical examination of input and output data collected for 53 Pennsylvania secondary schools during 1971-72. The set of data to be analyzed here is significant because it provides—perhaps for the first time—an opportunity to examine within a single input-output framework numerous school and nonschool inputs, as well as a variety of outputs, including not only test scores on basic skills but also attitudinal data and information on vocational development and creative output and potential. And while whatever conclusions that emerge apply at best only to the set of schools from which data were drawn, this analysis should form an interesting example of input-output analysis that can be adapted, modified, and implemented in other settings.

Chapter Five

The Pennsylvania Plan

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Since most of the data used in this study were accumulated by the Division of Educational Quality Assessment, Pennsylvania Department of Education, it is desirable to provide some information about the genesis, character, and development of the Pennsylvania Educational Quality Assessment (EQA) Program, also known as the Pennsylvania Plan.[a]

PURPOSES OF THE PLAN

On August 8, 1963, the Pennsylvania legislature passed the School Reorganization Act (Act 299). Section 290.1 of the act directed the State Board of Education to

> . . . develop or cause to be developed an evaluation procedure designed to measure objectively the adequacy and efficiency of the educational programs offered by the public schools of the Commonwealth. The evaluation procedure to be developed shall include tests measuring the achievements and performance of students pursuing all of the various subjects and courses comprising the curricula. The evaluation procedure shall be so constructed and developed as to provide each school district with relevant comparative data to enable directors and administrators to more readily appraise the educational performance and to effectuate without delay the strengthening of the district's educational program. Tests developed under the authority of this section to be administered to pupils shall be used for the purpose of providing a uniform evaluation of each school district and the other purposes set forth in this subdivision. The state Board of Educa-

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[a] This chapter is based on *Educational Quality Assessment in Pennsylvania* (1973). All page numbers refer to that publication.

> tion shall devise performance standards upon completion of the evaluation procedure required by this section (p. 6).

The need for such an evaluation was apparent when, in the hearings preceding the enactment of the Reorganization Act, both proponents and opponents of the measure relied on the elusive term "quality education" for defense of their respective positions. The obvious question then arose: "Just what *is* quality education?"

The legislation emphasizes the use of the data by school administrators in such a manner that the educational decision making process may be improved.

THE TEN GOALS OF QUALITY EDUCATION

In an effort to develop a comprehensive instrument that would be capable of satisfying the desire to measure educational quality, the Pennsylvania Department of Education has established the Ten Goals of Quality Education. The choice of the ten goals was made after consultation with "civic and professional leaders from throughout the state" (p. 7). These ten goals are summarized in Table 5-1.

Table 5–1. Pennsylvania's Ten Goals of Quality Education

Quality education should:

I. Help every child acquire the greatest possible understanding of himself or herself and appreciation of his or her worthiness as a member of society.

II. Help every child acquire understanding and appreciation of persons belonging to other social, cultural, and ethnic groups.

III. Help every child acquire, to the fullest possible extent, mastery of the basic skills in the use of words and numbers.

IV. Help every child acquire a positive attitude toward the learning process.

V. Help every child acquire the habits and attitudes associated with responsible citizenship.

VI. Help every child acquire good health habits and an understanding of the conditions necessary for maintaining of physical and emotional well-being.

VII. Give every child opportunity and encouragement to be creative in one or more fields of endeavor.

VIII. Help every child understand the opportunities open to him or her to prepare for a productive life and help each child to take full advantage of these opportunities.

IX. Help every child to understand and appreciate as much as possible of human achievement in the natural sciences, the social sciences, and the humanities and the arts.

X. Help every child to prepare for a world of rapid change and unforseeable demands in which continuing education throughout adult life should be a normal expectation.

Source: Educational Quality Assessment in Pennsylvania (1973), p. 5.

It is clear that the Pennsylvania Plan provides for a measurement of quality far different from the widespread use of expenditure data, quality of inputs, or merely achievement tests. The plan recognizes the importance of such goals as attitude modification (regarding such areas as citizenship, race relations, drug usage, and the learning process), vocational development, and creative output and potential.[b]

DATA COLLECTION

The process of data collection has undergone some changes since the inception of the plan. In the first phase (Fall 1968), the fifth and eleventh grades in 100 schools were selected throughout the state of Pennsylvania for the purpose of testing the reliability and content validity of the measures developed to assess attainment of the ten goals.

In Phase II of the plan (Fall 1969) "a stratified random sample of some 37,000 students in grades five and eleven in 428 different schools" was employed (p. 7). The data were gathered mainly for the purpose of studying the meaning of the numerical scores obtained for the various goals so that an interpretation of results could be provided to schools in subsequent testing.

Phase III marked the beginning of actual assessment. Beginning in Fall 1970, a number of schools have been assessed each year on the basis of voluntary participation. The samples for the period 1970-73 are summarized in Table 5-2. Currently, all schools are required by law to participate once every three years. In addition to testing fifth and eleventh grades, assessment will also be available for seventh, eighth, and ninth grades to satisfy the needs of middle and junior high schools.

ADMINISTRATION

To avoid what would amount to a monumental—and expensive—undertaking, local school districts must themselves administer the assessment. Data are gathered from pupils, teachers, and administrators. These data are sent to Harrisburg, where together with additional data on file, analysis of each school is carried out.

USE OF THE DATA

Each school receives a School Report containing the following information:

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[b] Additional information about the dimensions and measurement of the ten goals is containted in Appendix Table A-1.

Table 5-2. EQA Samples, 1970 to 1973

Year	*Number of districts*	*Number of schools*	*Grade level*	*Number of students*
Fall 1970–71	110	444	5	26,000
		89	11	24,000
Fall 1971–72	49	172	5	11,000
		53	11	12,000
Fall 1972–73	84	382	5	28,000
		90	11	29,000
Spring 1972–73	55	63	7	15,650
	96	148	9	34,850

Source: Educational Quality Assessment in Pennsylvania (1973), p. 8.

(i) The school's standing in the state on each of the Ten Goals of Quality Education.

(ii) The school's standing relative to schools operating with a similar set of resources—for example, the Appalachia school with limited resources is not expected to match the achievement of an affluent suburban school with a vastly different student body, faculty, and financial support.

(iii) The school's standing on each of the different resources (as many as 44) which are employed in setting the "level of expectation" cited in (ii) that "similar" schools are meeting.

(iv) How many high and low student scores there were which contributed to the average score—school score—cited in (i). Student replies to selected items.

or

Student replies to selected groups of items (subscales on each goal) (pp. 10–11).

It should be noted that the unit of analysis is the *school.* Data concerning individual students are not released, and in any event, students provide anonymous replies so that identification of individual replies is impossible. The relative standing on each of the ten goals is provided through the use of multiple regression analysis, in which each school's score is predicted on the basis of its standing on a number of explanatory variables.[c] Each school, then, can compare its actual standing with the predictive (relative) standing. The School Report also provides confidence intervals for the predicted scores.

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[c] See Campbell et al (1971). Many of the measures used as explanatory variables are described in Appendix Tables A-2 and A-3.

The EQA division claims that the results of the assessment program have induced a number of changes in the schools, including the following:

1. Faculty and students human relations meetings conducted.
2. Improved the "humanness" of the secondary faculty.
3. Changed emphasis in guidance, particularly in areas of self-esteem.
4. Revision of social studies curriculum.
5. Increased cultural program with ESEA Title I funds.
6. Concentration on knowledge of differing occupations.
7. Basic changes in reading and math program.
8. Health education program changed.
9. Teacher awareness of ten goals (p. 15).

CONCLUDING COMMENTS

The nature of the Pennsylvania Plan and the data collected provide a fertile ground for further input-output analysis of secondary schools. For the purposes at hand, data from the 1971-72 survey for 53 secondary schools have been combined with additional data collected by Kuhns (1972). The analysis here, moreover, will go beyond the School Report, providing additional management information to affected schools.

Chapter Six

Production Functions for Pennsylvania Secondary Schools

The need to employ a multidimensional set of educational outputs is widely recognized. We have seen that a few attempts have been made to study educational production processes in the context of a simultaneous-equations system in which several educational outputs interact.[a] The present chapter attempts to provide additional information about the input-output process by estimating a simultaneous-equation system of Pennsylvania secondary schools.

The present study has both advantages and drawbacks in comparison with previous studies. On the one hand we have the most extensive list of inputs and outputs (especially the latter) ever analyzed in a simultaneous-equation context. On the other hand we were not able to trace the data to the individual students and were thus forced to employ the school as the unit of analysis. Moreover, the results are based on an extremely small sample of only 53 secondary schools. We recognize these (and other) limitations of our data base, and will attempt to take them into account in the discussion of any implications of the present study. At the same time, the study's emphasis on manipulative inputs affords a discussion of the possibilities school management may have in improving operating efficiency—provided, of course, that our results are replicated and prove reasonably consistent across time and space.

THE DATA

The data for the study consist of the output and input variables for 53 Pennsylvania secondary schools in the fall of 1971. The output data are based on tests administered to students in the eleventh grade, whereas the input data are, in part, related to the entire school district, the entire high school, a portion of the high school, or the eleventh graders. Since the unit of observation for the input variables changes from one variable to the next, some problems of interpretation clearly arise. On the other hand, if the eleventh grade students can be considered to be representative of the secondary school students in the entire high school or the district, the weight of this problem is reduced. In any event, we were constrained by the availability of data, and had to make the best of available information.

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[a] The list includes Levin (1970), Michelson (1970), Fox (1971), and Boardman et al. (1973).

Some of the input variables were collected by Kuhns (1972) to supplement the data collected by the Pennsylvania Department of Education (PDE). These additional input variables comprise the majority of what we have called manipulative inputs, in line with a theoretical analysis presented elsewhere (Cohn, 1971).

The basic data used here are described in a summary form in Tables 6-1 and 6-2. (The variables are defined or described in more detail in Appendix Tables A-1 through A-4.) It should be noted that the list of input variables used here is only a subset of the PDE set since, as will be explained below, we have made use of principal components analysis to compress the remaining variables into a set of four socioeconomic variables, designated by SEFAC 1, SEFAC 2, SEFAC 3, and SEFAC 4. A brief description of the variables, by alphabetical order of the acronyms used, is provided in the Glossary.

THE MODEL

The specification of educational production functions has been described in some detail in the preceding chapters, therefore the discussion here will presume

Table 6–1. Output Variables: Definitions, Means, and Standard Deviations

Output	*Acronym*	*Description*[a]	*Mean*	*Standard Deviation*
1	GOAL I	Self Concept	89.41	1.38
2	GOAL II	Understanding Others	90.74	1.45
3	GOAL III-v	Verbal Basic Skills	16.08	1.35
4	GOAL III-m	Mathematical Basic Skills	18.24	1.30
5	GOAL IV	Interest in School	90.97	3.02
6	GOAL V	Citizenship	163.43	4.88
7	GOAL VI	Health Habits	119.58	2.75
8	GOAL VII-p	Creativity Potential	60.74	1.14
9	GOAL VII-o	Creativity Output	137.72	3.30
10	GOAL VIII	Vocational Development	83.12	0.83
11	GOAL IX	Appreciation of Human Accomplishments	153.93	3.25
12	GOAL X	Preparation for Change	106.15	2.23

[a] For a more detailed description consult Appendix Table A-1.

Table 6–2. Input Variables: Definitions, Means, and Standard Deviations

Acronym	*Description*[a]	*Mean*	*Standard Deviation*
LIBRARY	Accessibility of library	4.37	0.31
TPPOS	Teacher's number of years in present position	4.78	0.50
TCOLLEGE	Type of college from which teacher graduated	2.39	0.13
TLOCALE	Locale where teachers graduated from high school	4.31	0.16
TSTABL	Locale in which teachers spent most of their lives	4.40	0.19
TMEDUC	Educational level of teacher's mother	3.74	0.38
REACTL	Perception of actual characteristics influencing professional recognition	3.67	0.74
RECIDEA	Perception of ideal characteristics influencing professional recognition	1.70	0.26
TCAREER	Teacher career aspirations	7.24	0.69
TSATISF	Teacher satisfaction	19.89	1.09
DISCREP	Difference between real and ideal influences on educational process	4.74	0.52
CLPRACT	Teacher classroom practices	38.09	1.38
TSALARY	Teacher's salary	8205.66	562.50
TEXPER	Teacher's teaching experience	11.04	2.68
TEDUC	Teacher's education	4.75	0.29
STAFFP	Instructional personnel/pupil	0.05	0.0006
BOOKSP	Library books/pupil	10.87	3.68
GUIDANCE	Counselors/pupil	0.002	0.0005
INNOVATE	School usage of innovations	33.55	6.85
EFFORT	Property Taxes/Market Value	23.79	3.41
ADA	Average daily attendance	932.32	346.19
CUG	Curriculum units/grade	23.92	7.45
PRCO	Preparation coefficient (teacher specialization)	0.50	0.09
TLOD	Teacher load	20.05	1.85
CSIZ	Class size	24.29	5.61
AEE	Average extracurricular expenditure/pupil	66.47	21.67
BRAT	Ratio of actual enrollment to building capacity	1.08	0.23
AMAN	Administrative man hours/pupil	3.95	1.93
AXMAN	Auxiliary man hours/pupil	8.02	2.65
SFRAT	Student/academic faculty ratio	30.40	6.48
PSUP	Paraprofessional support	36.08	70.41

[a] For a more detailed description consult appendix Tables A–2 through A–4.

that the underlying production function is linear—hence the shape of the function is determined by Equation (3-2). However, the structure of the production process involves interaction among the outputs—a sort of feedback from one output to another. For example, achievement may be affected by attitudes, while attitudes might also be affected by achievement. In addition, attitude toward oneself might be affected by one's attitude toward school and society. Hence our model allows for such interactions, whether directly or indirectly, by specifying a simultaneous-equation system.

Consider n educational outputs, $Q_1, Q_2, \ldots, Q_n$, k school inputs, $X_1, X_2, \ldots, X_k$, and m nonschool inputs, $Z_1, Z_2, \ldots, Z_m$. Then a generalized system of equations describing the educational production process would have the fofowing form:

$$\begin{aligned} Q_1 &= f_1\,(Q_2, Q_3, \ldots, Q_n; X_1, X_2, \ldots, X_k / Z_1, Z_2, \ldots, Z_m; u_1) \\ Q_2 &= f_2\,(Q_1, Q_3, \ldots, Q_n; X_1, X_2, \ldots, X_k / Z_1, Z_2, \ldots, Z_m; u_2) \\ &\;\;\vdots \\ Q_n &= f_n\,(Q_1, Q_2, \ldots, Q_{n-1}; X_1, X_2, \ldots, X_k / Z_1, Z_2, \ldots, Z_m; u_n) \end{aligned} \tag{6-1}$$

where the u's denote stochasitc error terms. The output variables (the Q's) are considered to be endogenous variables and the input variables (the X's and the Z's) exogenous in this system.

The equation system must be reduced to a statistically estimable model. Some simplification of that system can be achieved through a priori examination of the equations. For example, it might be argued that vocational development is entirely independent of achievement in verbal skills, implying that some of the outputs in each of the equations are likely to have a coefficient that should not differ significantly from zero. Similarly, not every input in either the school or nonschool variable sets is relevant in each of the equations. In addition, since the number of observations is only 53, the number of independent (explanatory) variables in any equation is obviously restricted. Furthermore, if it is desired to obtain reliable coefficients for the manipulative input variables, an effort must be made to reduce the degree of multicolinearity in the data set.

Several approaches may be followed to overcome these problems. One would be to select variables for each equation on the basis of their contribution to explaining the output variance. In this method, one would continue adding explanatory variables to the equation until the addition to R^2 (the coefficient of determination) is less than a prespecified amount. This amount might be set arbitrarily, or, alternatively, one could terminate the addition of variables when the difference between the R^2 derived *when* the new variable is added and the R^2 derived *before* the variable was added is not statistically significant.

Another alternative would be to employ principal components or factor analysis to derive a set of new variables from the original input set. The new set of variables would contain fewer factors representing most of the variation in the original data set, thus increasing the number of degrees of freedom and the reliability of the coefficient estimates. However, the new factors so produced are usually difficult to interpret, so that the use of factor or principal components analysis is obviously limited.

A third possibility would be to combine a priori specification with factor analysis. For example, if one wishes to examine the effect of various manipulative variables on educational output, it would be necessary to express these factors in their original units. However, there is no need to specify in the equation all (or some subset of) the vectors of environmental and nonmanipulative school inputs. Instead, principal components of the latter two groups may be computed and entered in the equation along with those manipulative variables that are thought to belong in the equation a priori.[b]

A combination of these possibilities has been employed to derive a specification for the simultaneous-equation system. The specification of the full model is provided in Table 6-3 and described more fully in the following paragraphs.

Specifying the Endogenous (Output) Variables

Each of the twelve equations contains a number of both endogenous and exogenous variables. The choice of endogenous variables in the twelve equations was influenced by (1) the degree of (zero order) correlation among the relevant outputs, and (2) a priori analysis. The a priori analysis was used mainly to reduce the number of endogenous variables in each equation. The degree of correlation was taken from a previous study of the Pennsylvania data by Donaldson (1971), based upon an earlier PDE sample. In summary, then, endogenous variables were chosen in a given equation when they appeared to have relatively high correlations with the respective dependent variable—provided, however, that an a priori argument could support their inclusion in the model.

Specifying the Set of Exogenous Variables

The job of specifying the exogenous set was far more complicated. The main constraint was the lack of degrees of freedom. In addition, the specification was influenced by the desire to investigate as many of the instrumental (manipulative) variables as possible.

[b] Such a suggestion is made by Kendall (1957), pp. 70-74, cited in Johnston (1972), p. 329.

Table 6–3. Simultaneous–Equations Model

Equation/Output	*Endogenous Variables*	*Exogenous Variables*
1. Goal I	Goal III-v, Goal III-m Goal IV, Goal VI, Goal VII-p, Goal VIII, Goal IX	TEDUC, EFFORT, GUIDANCE, TLOD, CSIZ AEE, AMAN, AXMAN, SEFAC 1, SEFAC 2, SEFAC 3, SEFAC 4
2. Goal II	Goal III-v, Goal III-m	TCOLLEGE, DISCREP, TSALARY, EFFORT, ADA, TLOD, CSIZ, AEE, BRAT, PSUP. SEFAC 1, SEFAC 2, SEFAC 3, SEFAC 4
3. Goal III-v	Goal I, Goal II, Goal III-m Goal VI, Goal VIII	TEXPER, STAFFP, ADA, CUG, TLOD, AEE, AMAN, AXMAN, SEFAC 1, SEFAC 2, SEFAC 3, SEFAC 4
4. Goal III-m	Goal I, Goal II, Goal III-v Goal VI, Goal VIII	CUG, PRCO, TLOD, AEE, AXMAN, PSUP, SEFAC 1, SEFAC 2, SEFAC 3, SEFAC 4
5. Goal IV	Goal I, Goal V, Goal VI, Goal IX	LIBRARY, TPPOS, TSATISF, TSTABL, TSALARY, AEE, BRAT, AXMAN, SFRAT, SEFAC 1, SEFAC 2, SEFAC 3, SEFAC 4
6. Goal V	Goal IV, Goal VI, Goal VII-o Goal VIII, Goal IX	LIBRARY, TCOLLEGE, GUIDANCE, TLOCALE, ADA, CUG, TLOD, CSIZ, AMAN, AXMAN, SEFAC 1, SEFAC 2, SEFAC 3, SEFAC 4
7. Goal VI	Goal I, Goal III-v, Goal III-m Goal IV, Goal V, Goal VII-o, Goal VIII, Goal IX	TSALARY, CUG, TLOD, AEE, BRAT, AXMAN, SFRAT, PSUP, SEFAC 1, SEFAC 2, SEFAC 3, SEFAC 4
8. Goal VII-p	Goal I, Goal VII-o, Goal VIII, Goal IX, Goal X	TSALARY, PRCO, SFRAT, SEFAC 1, SEFAC 2, SEFAC 3, SEFAC 4
9. Goal VII-o	Goal V, Goal VI, Goal VII-p	TSTABL, TSALARY, TEDUC, TLOD, CSIZ, BRAT, AXMAN, PSUP, SEFAC 1, SEFAC 2, SEFAC 3, SEFAC 4
10. Goal VII	Goal I, Goal III-v, Goal III-m Goal V, Goal VI, Goal VII-p Goal IX	TMEDUC, REACTL, TSALARY, TEXPER, CUG, PRCO, TLOD, CSIZ, AXMAN, SEFAC 1, SEFAC 2, SEFAC 3, SEFAC 4
11. Goal IX	Goal I, Goal IV, Goal V, Goal VI, Goal VII-p, Goal VIII, Goal X	TCOLLEGE, RECIDEA, TSALARY, CUG, TLOD, SFRAT, ADA, SEFAC 1, SEFAC 2, SEFAC 3, SEFAC 4
12. Goal X	Goal VII-p, Goal IX	GUIDANCE, BOOKSP, CLPRACT, TSATISF, TCAREER, INNOVATE, ADA, CUG, TLOD, CSIZ, AMAN, PSUP, SEFAC 1, SEFAC 2, SEFAC 3, SEFAC 4

Because of the focus on instrument variables, it was decided to utilize Kendall's suggestion (cited above) and employ principal components analysis to reduce a large number of potentially relevant inputs into a small set of factors. We chose to use only four factors, which together explain in excess of 70 percent of the variation in the original variable set. As noted earlier, the four factors are denoted by SEFAC 1 through SEFAC 4. The variables from which these factors were drawn are briefly described in Table 6-4.

For the remaining exogenous variables, the step-up, ordinary least squares

Table 6-4. Variables Included in the Four Socioeconomic Factors

Acronym	*Definition*
SEX	Sex of student (1 = male, 2 = female)
RACE	Race of student (1 = "other," 2 = black, 3 = Puerto Rican, 4 = American Indian, 5 = white, 6 = Oriental)
ATTEND	The number of days a student was absent in the past school year
FOCC	The student's father's education (based on a weighting from 0 to 96 according to a combination of education needed to secure the occupation and income derived from the occupation)
MOCC	The student's mother's occupation. Index is similar to the one used for FOCC, and computed for mothers who were gainfully employed
PCTMW	Percentage of mothers working
FAMSES	Family socioeconomic status, a composite of MOCC and FOCC for the school
MORESB	Mores–boys: student's perception of the single best way for a boy to be important or looked up to by other students in his school
MORESG	Mores–girls: similar to MORESB
VALUES	Student's assessment to that quality which was most important to him (her) personally regardless of what others may choose; scales used for MORESB and MORESG were used here, too
SUBSIDY	State instructional subsidy per pupil in weighted average daily membership paid to the school district
LOCATION	Type of community in which the student lives (1 = open country, 2 = city over 500,000, 3 = town less than 10,000, 4 = city 100,000–500,000, 5 = city 10,000–100,000, 6 = suburb of city 10,000–100,000, 7 = suburb of city 100,000–500,000, 8 = suburb of city over 500,000)
INTERRAC	Whether or not students came in contact with students of a race different from their own in their classes or school activities (1 = no, 2 = yes)
HOUSING	Percentage of various types of housing units in the area served by the school (1 = low rental apartments, 2 = low cost homes, 3 = moderate rental apartments, 4 = moderate priced homes, 5 = high rental apartments, 6 = expensive private homes)

Source: Adapted from Russell (1971), pp. 5–7, and 15–18.

regression process, as used by Kuhns with the same data, formed the initial basis for the specification. All exogenous variables contributing a minimum of one percentage point to R^2 were allowed to enter (or reenter) the equation. The final equation was chosen when no changes in the equation could increase R^2 by at least .01.

Not all the variables so chosen by Kuhns were included in the present model, however. First, some of the variables chosen by Kuhns appear to represent educational output more than input. For example, there is the variable HOLDING—the inverse of the dropout rate—which is clearly more an output than an input. Furthermore, some of the variables in the Kuhns model are clearly not independent of one another. For example, two measures of school size are used—enrollment and ADA. Since the correlation between the two is extremely high, the two variables essentially serve as proxies for a single input, and inclusion of both in any single equation only serves to distort the reliability of the respective coefficients.

It is quite obvious that the specification employed here is far from ideal, and would probably invite some criticisms. What should be kept in mind, however, is that first, our survey of the literature failed in general to provide consistent findings that would suggest the inclusion of certain variables, a priori. In addition, there is very little prior empirical information on the relationship between the outputs (excluding achievement) and the set of inputs used here. And finally, that what is presented here should not be considered as a final specification but rather as one plausible specification of the simultaneous-equation system.

REGRESSION RESULTS

An inspection of Table 6-3 would indicate that the model satisfies the necessary (though not necessarily sufficient) conditions for identification. In fact it is overidentified. This is based on the popular counting rule, which requires that the number of exogenous variables excluded from each equation must be equal to or exceed the number of endogenous variables included in the respective equations less one.[c] In consequence, we can estimate the coefficients in the twelve equations by employing the widely used two stage least squares (TSLS) procedure.[d]

[c] For example, if five outputs (endogenous variables) are included in the first equation, the maximum number of exogenous variables that may be included in the equation is k-5-1, where k is the number of exogenous variables in the entire equation set. See Johnston (1972), p. 359.

[d] The issues of identification and estimation regarding systems of equations are treated adequately in numerous econometric text books. Excellent analyses may be found in Hu

The TSLS procedure provides estimates of the structural coefficients including both endogenous and exogenous variables. The structural coefficients of the exogenous variables, however, provide only a partial picture. The full effect of any input on a given output also includes the effect of that input on other outputs in the system, so long as the various outputs are not statistically independent. To obtain measures of the full contribution of the exogenous variables to each of the outputs, the reduced form equations must be estimated. The reduced form coefficients are, essentially, the solutions of the system of twelve equations in twelve unknowns, the exogenous variables being treated as givens.

The analysis in this section will focus on the results pertaining to the manipulative variables. The results will be discussed in the context of the structural coefficients, the reduced form coefficients derived therefrom, and reduced form coefficients based on the use of ordinary least squares (OLS) analysis, in which the entire set of exogenous variables is regressed separately on each of the twelve outputs. The major focus will be centered on the reduced form coefficients.

The standard errors of the reduced form coefficients were estimated using a technique described by Theil (1961, p. 342). These are known as asymptotic standard errors, implying that we know very little about their small sample properties. However, Goldberger suggests that "hypothesis testing and interval estimation may be carried out by the standard procedures" (Goldberger, 1964, p. 371). Readers wishing a more detailed description of the results will find additional information in Appendix Table A-5. The table provides all the structural and reduced form coefficients for the simultaneous system, as well as the OLS coefficients described above.

Self Concept

The structural equation for Goal I includes seven manipulative variables, as may be observed from Table 6-5. A casual comparison of the structural and reduced form coefficients indicates that the latter are, with one exception (AEE), greater in absolute value. This is not surprising, as the structural coefficients only describe a partial effect of the inputs on Self Concept.

Among the structural coefficients there is only one significant variable—AMAN. Moreover, the negative sign is puzzling, since a simple a priori analysis would suggest a positive sign, ceteris paribus. On the other hand, the reduced form coefficients indicate an increased role for the instrument variables, despite the fact that AMAN is still negative, and that its coefficient is even larger in absolute value. The three variables whose coefficients appear to be significantly

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(1973), Chapter 7—for readers desiring a description involving a minimum of mathematics—and Johnston (1972), Chapters 12 and 13, for the more mathematically inclined readers. Advance treatments may be found in Goldberger (1964) and Theil (1961).

Table 6–5. Production Function Estimates for Manipulative Inputs – Goal I (Partial Regression Coefficients and, in Parentheses, Standard Error)

	Simultaneous System		
Inputs	*Structural*	*Reduced Form*	*OLS*
TEDUC	0.508 (0.475)	0.904 (0.764)	0.056 (1.166)
GUIDANCE	57.389 (298.007)	110.3 (512.1)	1130.148 (569.182)
TLOD	-0.046 (0.082)	-0.307 (0.096)	-0.233 (0.154)
CSIZ	-0.008 (0.027)	-0.014 (0.041)	0.210 (0.086)
AEE	-0.011 (0.007)	-0.007 (0.010)	-0.014 (0.015)
AMAN	0.042 (0.094)	0.265 (0.127)	0.148 (0.147)
AXMAN	-0.121 (0.058)	-0.216 (0.076)	-0.131 (0.134)

different from zero are TLOD, AMAN, and AXMAN. Taking TLOD as an example, a no-nonsense interpretation of the results would suggest that for each one hour increase in teaching load, the score on Self Concept is likely to decrease by approximately three-tenths of a point. Although this seems a small reduction in the Self Concept score relative to its mean, note that the standard deviation of Goal I is only 1.38, so a decrease of one hour in TLOD will contribute to a reduction in Goal I *greater* than 22 percent of the standard deviation. Similarly, an increase in AMAN of one man year is likely to contribute to an increase of 0.266 in the Self Concept score, other things being equal.

We note that the OLS estimates are considerably different from both the structural and reduced form coefficients. GUIDANCE has a coefficient of almost ten times that of the reduced form coefficient, while the coefficient of CSIZ is both positive and statistically significant. Some of these differences, moreover, are also statistically significant. If the specification of the model is accepted, then the OLS technique appears to provide at least some biased coefficients.

Understanding Others

None of the coefficients in Table 6-6 is significant at the 5 percent level for a two-tailed t test. The coefficient with the largest t ratio is the one for BRAT. Although the sign of the coefficient is consistent with expectation, the results of this equation are clearly disappointing.

Table 6–6. Production Function Estimates for Manipulative Inputs – Goal II (Partial Regression Coefficients and, in Parentheses, Standard Error)

	Simultaneous System		
Inputs	*Structural*	*Reduced Form*	*OLS*
TSALARY	0.0002 (0.0003)	0.0002 (0.0003)	0.001 (0.001)
TLOD	0.157 (0.100)	0.141 (0.091)	0.002 (0.173)
CSIZ	-0.040 (0.030)	-0.040 (0.030)	0.016 (0.097)
AEE	0.010 (0.010)	0.011 (0.010)	0.015 (0.017)
BRAT	-1.161 (0.668)	-1.170 (0.662)	-2.108 (1.114)
PSUP	-0.001 (0.002)	-0.001 (0.002)	0.005 (0.003)

Verbal Skills

The results for this equation are of particular interest (as are the results for the next equation) because of the focus that has been placed upon achievement as the most important–if not the sole–educational output. The results, reported in Table 6-7, provide both positive and negative conclusions. Beginning with the latter, teachers' salaries do not appear to be significant here, unlike re-

Table 6–7. Production Function Estimates for Manipulative Inputs – Goal III-v (Partial Regression Coefficients and, in Parentheses, Standard Error)

	Simultaneous System		
Inputs	*Structural*	*Reduced Form*	*OLS*
TSALARY	-0.008 (0.036)	0.0002 (0.0002)	0.001 (0.001)
CUG	-0.008 (0.015)	-0.039 (0.022)	-0.027 (0.038)
TLOD	-0.131 (0.067)	-0.245 (0.072)	-0.111 (0.153)
AEE	0.012 (0.005)	0.017 (0.007)	0.006 (0.015)
AMAN	0.144 (0.052)	0.243 (0.079)	0.167 (0.134)
AXMAN	-0.049 (0.043)	-0.113 (0.056)	-0.012 (0.134)

sults obtained by many investigators. On the other hand, the coefficients of TLOD, AEE, and AMAN are both significant and have the expected signs. The same cannot be said, however, of CUG and AXMAN, which consistently display unexpected negative signs. Regarding CUG, the negative sign might reflect the effect of other variables correlated with CUG, such as school size or urban vs. rural location. The negative coefficient of AXMAN might be explained on the basis of a possible trade-off between auxiliary manpower and instructional or other academic staff. It is possible that many educational outputs are not influenced by the investment in auxiliary personnel, and, if such investment reduces funds for other inputs, the total output may be reduced.

Mathematical Skills

Table 6-8 provides the results for this output. Out of the six manipulative variables included in the specification, three reduced form coefficients are statistically significant: CUG, TLOD, and PSUP. However, only the TLOD coefficient has the expected sign. The negative coefficient for PSUP might be explained, again, on the basis of a trade-off argument. For a fixed sum a school can hire either paraprofessionals or other inputs, such as teachers' or administrators' services. If the paraprofessionals are not as productive as expected, then schools using fewer paraprofessionals and more of other inputs will have a greater output. Our results appear to suggest, therefore, that paraprofessional aides are far less productive than what some may have led us to believe. Inci-

Table 6–8. Production Function Estimates for Manipulative Inputs – Goal III-m (Partial Regression Coefficients and, in Parentheses, Standard Error)

	Simultaneous System		
Inputs	*Structural*	*Reduced Form*	*OLS*
CUG	-0.030 (0.021)	-0.053 (0.026)	-0.069 (0.048)
PRCO	-0.115 (1.645)	0.292 (2.038)	3.590 (5.867)
TLOD	-0.046 (0.083)	-0.184 (0.086)	-0.137 (0.193)
AEE	0.004 (0.007)	0.012 (0.009)	-0.009 (0.019)
AXMAN	-0.005 (0.048)	-0.086 (0.066)	-0.052 (0.168)
PSUP	-0.004 (0.002)	-0.005 (0.002)	-0.007 (0.004)

dentally, as will be seen later, the negative sign for PSUP persists in other equations, as is the case for CUG.

Interest in School

The results of this equation, reported in Table 6-9, again provide both positive and negative conclusions. The positive conclusions indicate that greater access to the library and higher average teacher salaries contribute positively to interest in schools—results that are consistent with a priori expectations. The negative conclusions are equally important, indicating that interest in school might not be increased when additional funds are spent on extracurricular activities or when overcrowding is avoided. Also, although the reduced form coefficient of SFRAT has the expected sign (suggesting that interest in school is higher when lower student-to-faculty ratios are maintained), the coefficient is not significantly different from zero.

Three variables not included in the structural model are also significant in the reduced form equation: TSTABL, TSATIS, and TLOD. The latter in particular is highly significant, indicating the strong influence of this variable through the interaction of other outputs with interest in school.

Citizenship

Four out of seven manipulative variables reported in Table 6-10 are statistically significant. Further, the signs of the coefficients of LIBRARY, TLOD,

Table 6–9. Production Function Estimates for Manipulative Input – Goal IV (Partial Regression Coefficients and, in Parentheses, Standard Error)

	Simultaneous System		
Inputs	*Structural*	*Reduced Form*	*OLS*
LIBRARY	1.489 (0.887)	3.260 (1.191)	3.334 (1.996)
TSALARY	0.001 (0.001)	0.002 (0.001)	0.002 (0.001)
AEE	-0.013 (0.016)	-0.017 (0.020)	-0.043 (0.032)
BRAT	-2.003 (1.348)	-1.295 (1.542)	-4.367 (2.044)
AXMAN	-0.086 (0.115)	-0.249 (0.155)	-0.020 (0.276)
SFRAT	0.0004 (0.060)	-0.031 (0.074)	0.022 (0.158)

Table 6–10. Production Function Estimates for Manipulative Inputs – Goal V (Partial Regression Coefficients and, in Parentheses, Standard Error)

	Simultaneous System		
Inputs	*Structural*	*Reduced Form*	*OLS*
LIBRARY	2.522 (1.167)	5.857 (2.231)	3.039 (3.434)
GUIDANCE	-698.117 (840.144)	-506.6 (1608.00)	1825.001 (2017.403)
CUG	-0.081 (0.062)	-0.319 (0.116)	0.084 (0.135)
TLOD	0.012 (0.222)	-0.809 (0.355)	-0.572 (0.546)
CSIZ	-0.052 (0.069)	-0.110 (0.130)	0.079 (0.306)
AMAN	0.564 (0.189)	1.363 (0.423)	0.476 (0.520)
AXMAN	-0.008 (0.149)	-0.246 (0.265)	-0.501 (0.475)

and AMAN are consistent with a priori expectations. Also, the coefficient of CSIZ has the expected sign, although it is not statistically significant. We note, too, that the reduced form coefficient of TSALARY, not reported in the table (see Appendix Table A–5), is positive and significant, reflecting its indirect influence on citizenship via the interaction of other outputs with citizenship.

Health Habits

Virtually all the manipulative variables for this output, with the exception of AEE, have significant coefficients–although the signs of CUG, AMAN, and PSUP[e] are in the unexpected direction (see, however, our earlier comments on these variables)–as may be seen in Table 6-11. The effect of overcrowding is particularly interesting: a one standard deviation increase in BRAT (i.e., an increase in overcrowding) will increase the health habits score by 0.543, which is equal to almost 20 percent of a one standard deviation in the health habits output. Similar effects can also be calculated for TLOD and SFRAT. One could also increase the score of health habits through changes in teacher salaries. To increase the score by one standard deviation would require an increase in average teacher salaries of approximately $1,375, which is slightly more than two standard deviations of the TSALARY variable.

[e] The negative coefficient of PSUP is not really all too perplexing if the paraprofessionals are recruited from those groups in society who are accustomed to less rigid health habits.

Table 6–11. Production Function Estimates for Manipulative Inputs – Goal VI (Partial Regression Coefficients and, in Parentheses, Standard Error)

	Simultaneous System		
Inputs	*Structural*	*Reduced Form*	*OLS*
TSALARY	-0.001 (0.001)	0.002 (0.001)	-0.001 (0.001)
CUG	-0.075 (0.047)	-0.133 (0.048)	-0.044 (0.074)
TLOD	-0.330 (0.168)	-0.566 (0.173)	-0.608 (0.298)
AEE	0.021 (0.016)	0.014 (0.015)	0.018 (0.030)
BRAT	1.824 (1.378)	2.361 (1.229)	0.226 (1.920)
AXMAN	-0.122 (0.114)	-0.213 (0.110)	-0.286 (0.259)
SFRAT	-0.093 (0.051)	-0.119 (0.051)	-0.097 (0.149)
PSUP	-0.011 (0.005)	-0.012 (0.004)	-0.008 (0.006)

Creative Potential

Two out of the three variables included in the structural model and reported in Table 6–12 are significant: TSALARY and PRCO. (In the structural equation the two are PRCO and SFRAT.) The sign of PRCO is positive, suggesting that greater diversity of subject matter assignment among the teachers contributes to development of creative potential in students. The highly significant coefficient for TSALARY is suggestive of the role teachers play in enhancing creative potential.

Table 6–12. Production Function Estimates for Manipulative Inputs – Goal VII-p (Partial Regression Coefficients and, in Parentheses, Standard Error)

	Simultaneous System		
Inputs	*Structural*	*Reduced Form*	*OLS*
TSALARY	0.0002 (0.0002)	0.001 (0.0004)	0.001 (0.001)
PRCO	3.680 (1.615)	5.658 (2.278)	2.067 (4.939)
SFRAT	0.056 (0.020)	0.056 (0.031)	0.048 (0.081)

Table 6–13. Production Function Estimates for Manipulative Inputs – Goal VII-o (Partial Regression Coefficients and, in Parentheses, Standard Error)

	Simultaneous System		
Inputs	*Structural*	*Reduced Form*	*OLS*
TSALARY	0.002 (0.001)	0.002 (0.001)	0.002 (0.002)
TEDUC	-2.426 (1.672)	-2.604 (1.833)	-4.041 (3.568)
TLOD	0.103 (0.229)	0.078 (0.245)	0.478 (0.471)
CSIZ	0.063 (0.080)	0.083 (0.084)	0.197 (0.265)
BRAT	-5.959 (1.844)	-5.798 (1.829)	-2.063 (3.037)
AXMAN	-0.265 (0.151)	-0.293 (0.163)	0.464 (0.411)
PSUP	0.007 (0.006)	0.006 (0.006)	-0.003 (0.010)

Creativity Output

The results for this output are displayed in Table 6-13, indicating only two significant inputs: TSALARY and BRAT. The sign of BRAT implies that increased creative productivity is associated with a lower ratio of enrollment to building capacity—that is, when buildings are less crowded. Although the coefficient of TEDUC is not statistically significant, its negative sign suggests the hypothesis that teachers who on the average obtain more educational preparation are likely to focus more on academic achievement than on creative output.

Vocational Development

Four out of the seven manipulative variables reported in Table 6-14 are significant: TSALARY, CUG, PRCO, and TLOD. The negative coefficient of CUG is, again, somewhat puzzling (note, however, our earlier comments). TSALARY and TLOD continue to show a consistent impact on output, whereas the positive coefficient of PRCO again indicates that diversity in subject matter assignment might be an advantage in this case rather than a disadvantage, as one might have expected on the basis of the application of a finer division of labor and increased teacher specialization. The negative coefficient of TEXPER is interesting, although it is not significantly different from zero, at the 5 percent level, for a two-tailed test. In addition, the reduced form coefficient of AMAN, not included in the structural model, is significantly positive.

Table 6–14. Production Function Estimates for Manipulative Inputs – Goal VIII (Partial Regression Coefficients and, in Parentheses, Standard Error)

	Simultaneous System		
Inputs	*Structural*	*Reduced Form*	*OLS*
TSALARY	0.0003 (0.0002)	0.001 (0.0002)	0.001 (0.0004)
TEXPER	-0.064 (0.038)	-0.099 (0.056)	-0.075 (0.099)
CUG	-0.025 (0.010)	-0.059 (0.019)	-0.029 (0.024)
PRCO	3.805 (0.891)	5.169 (1.421)	2.589 (2.947)
TLOD	-0.072 (0.040)	-0.233 (0.060)	–0.195 (0.097)
CSIZ	0.007 (0.015)	-0.002 (0.024)	0.117 (0.054)
AXMAN	0.023 (0.026)	-0.075 (0.044)	-0.081 (0.084)

Appreciation of Human Accomplishments

Table 6-15 has the results for this output. Three out of the four variables have significant coefficients: TSALARY, CUG, and TLOD. The results here are similar to results discussed earlier for the same variables. The coefficient of SFRAT is not significant but has the expected sign. We also note that the coefficient of AMAN, again not included in the structural model, is positive and significant in the reduced form equation.

Table 6–15. Production Function Estimates for Manipulative Inputs – Goal IX (Partial Regression Coefficients and, in Parentheses, Standard Errors)

	Simultaneous System		
Inputs	*Structural*	*Reduced Form*	*OLS*
TSALARY	0.001 (0.001)	0.002 (0.001)	-0.0001 (0.002)
CUG	-0.024 (0.044)	-0.208 (0.083)	0.052 (0.097)
TLOD	-0.204 (0.151)	-0.656 (0.283)	-0.667 (0.389)
SFRAT	-0.091 (0.054)	-0.012 (0.084)	-0.105 (0.194)

Preparation for Change

The final equation, with manipulative coefficients summarized in Table 6-16, contains nine variables, six of which have statistically significant coefficients: CLPRACT, GUIDANCE, INNOVATE, CUG, TLOD, and AMAN. An examination of the full reduced form equation indicates that TSALARY is also positive and significant.

Of interest here are the variables CLPRACT, GUIDANCE, and INNOVATE. It appears that the extent to which schools employ innovative practices has opposite implications on preparation for change depending on whose perception we rely. Taking teachers' perception, the effect is negative (CLPRACT); taking the administration's viewpoint, the effect is positive (INNOVATE). However, since the zero order correlation between INNOVATE and CLPRACT is only 0.10 (with 53 observations), the two variables clearly serve as proxies for different inputs, and thus the opposite signs should not be too surprising. What is important to note is the fact that use of innovative techniques appears to have some impact on this output. The choice of educational methodologies, moreover, is up to the school administration, and changes in methodology might be attained at a very little resource cost to the school district.

Table 6–16. Production Function Estimates for Manipulative Inputs – Goal X (Partial Regression Coefficients and, in Parentheses, Standard Errors)

	Simultaneous System		
Inputs	*Structural*	*Reduced Form*	*OLS*
CLPRACT	-0.460 (0.172)	-0.536 (0.214)	-0.116 (0.380)
BOOKSP	-0.090 (0.074)	-0.105 (0.085)	-0.518 (0.211)
GUIDANCE	1453.498 (472.002)	1656.0 (585.2)	2325.712 (1437.762)
INNOVATE	0.088 (0.036)	0.103 (0.042)	0.095 (0.144)
CUG	-0.169 (0.041)	-0.216 (0.049)	0.052 (0.097)
TLOD	-0.231 (0.169)	-0.374 (0.193)	-0.667 (0.389)
CSIZ	0.037 (0.055)	0.032 (0.066)	0.127 (0.218)
AMAN	0.377 (0.136)	0.538 (0.193)	0.161 (0.370)
PSUP	-0.004 (0.003)	-0.006 (0.004)	-0.015 (0.008)

The positive sign for GUIDANCE indicates the effect of the employment of guidance counselors on the formation of attitudes. Unless the set of outputs also contains attitudinal measures, the impact of a number of potentially important school inputs may go unnoticed, erroneously concluding that expenditures on such inputs should be reduced or eliminated.

We also note that the coefficient of TSALARY in the reduced form equation is significantly positive, despite its exclusion from the structural equation.

Further Observations

The general goodness of fit of the model, measured by the coefficient of determination, R^2, is generally quite satisfactory for models of this type. While it is beyond question that nonschool variables contribute a large portion of the explanatory power of the model, it is equally beyond question that school related factors are also important. While some might be disappointed with the results, it cannot be denied that school factors, including a number of manipulative variables, *are* statistically significant determinants of output. The results confirm our expectation that investment in school resources does matter, and that reallocation of resources by the school administrator is almost certain to result in increased output per unit of input.

Nevertheless, it should be reemphasized that additional validation and reaffirmation of the results must be forthcoming before substantial changes in the allocation of resources within the school system can be recommended. Of course, to the extent that the results confirm what educators would have believed on a priori analysis alone, there is no reason to be excessively concerned over the various problems plaguing the model. Results which conflict with accepted opinions should be viewed with caution, of course, especially since we are not sure whether each of the inputs employed in the model is a proper proxy for the input under study.

At the very least, our results suggest a number of intriguing hypotheses concerning the relationship between various inputs and outputs, which should receive further investigation. For example, our results point to a negative correlation between PSUP and output. Is this because of errors in the variable, because of intercorrelation with other variables, or perhaps because of the trade-off theory suggested above? Or consider the negative sign we consistently get for CUG. Is that due to intercorrelation with other variables such as school size (the zero order correlation coefficient between CUG and ADA is 0.42, n = 53), or is it really true that increasing the breadth of the curriculum actually results in reduced output, as measured by the set of output scores used here? Finally, is the negative sign we find for AXMAN in several equations indicative of some kind of a trade-off between instructional staff and auxiliary manpower, or is it simply the result of some statistical artifacts? Such questions may be answered satisfactorily only after the model has beeen modified, replicated, and retested under various circumstances over time and space.

APPLICATIONS OF THE SIMULTANEOUS-EQUATIONS RESULTS

In discussing the results of the model, primary attention has been focused on the level of significance and sign of the regression coefficients. We have not attempted to provide guidance regarding the possible uses of the results. We attempt to fill the gap in this section.

A word of caution may be appropriate at the outset. It should be recognized that the results reported in this study cannot be accepted uncritically. There are problems in the collection of the data, in the reliability of both output and input measures, in the considerable intercorrelation that remains in the various equations despite efforts to reduce it, and finally in the specification of the model. What follows is a description of what *could* be done with such results once one is reasonably satisfied that both the data and the underlying model are sound.

Internal Reallocation of Resources

School principals could, in principle, be given sufficient flexibility to reallocate resources within their schools, subject to some constraints, so long as total expenditures remain fixed. For example, a secondary school principal might be given an option to choose between the following: (1) hire ten teachers at the average salary of $10,000, or (2) hire fifteen teachers at an average salary of $6,667. In the first instance the typical teacher might possess greater previous experience and/or educational training than would be the case in the second option. However, with fifteen teachers, the principal could expand the curriculum, and/or reduce the teaching load, and/or reduce the average class size (provided enough classroom space is available).

Suppose, for example, that a school has an enrollment of 100 pupils and offers 200 academic hours per week of instruction. If ten teachers are hired, the teacher-pupil ratio would be 0.1, and the average teaching load would be twenty hours per week. If fifteen teachers are hired, the teacher-pupil ratio would be 0.15, and the teaching load would be only 13.3 hours per week. Suppose further that the school principal wishes to increase the students' verbal skills, and that the average experience of the two sets of teachers would be identical (the only difference between the two sets being the average educational level). From Appendix Table A-5 it is seen that the coefficients for the teacher-pupil ratio

(STAFFP) and teaching load (TLOD), respectively, are 22.359 and -0.245. The difference between the two options is given by a reduction in teaching load of 6.67 and an increase in the teacher-pupil ratio of 0.05. The total effect is given by:

$$\begin{aligned}\text{Change in Verbal Score} &= 22.359\,(0.05) - 0.245\,(-6.67)\\ &= 1.12 + 1.63\\ &= 2.75\end{aligned}$$

That is, the replacement of the ten expensive teachers by the fifteen less expensive ones would result in an increase in the verbal skills score of 2.75—more than a 17 percent increase over the mean score for the 53 Pennsylvania schools.

It should be noted that no offsetting reductions in the verbal scores are calculated for the possible effect of the reduction in teacher "quality" (resulting from hiring less expensive teachers) on verbal skills. If the reduction in teacher quality results from hiring teachers with less experience, then an offsetting reduction is apparently not needed: the coefficient of TEXPER for this equation is *negative.* However, if the reduction in teacher quality is the result of hiring teachers with less educational preparation, then some adjustment should be made, since the coefficient of TEDUC is positive for this equation. In this case we should continue to substitute less expensive teachers for more expensive ones so long as the *net* expected change in verbal score is positive.

The results indicate the potential improvements in verbal skills that may be reaped by changing the mix of teachers. This is not quite so easy to implement as it may seem at first sight, because teacher hiring and firing is often subject to collective bargaining agreements. Furthermore, school principals all too often have no decision making latitude in this respect. Nevertheless, the results do indicate an area where internal reallocation of resources might enhance the productivity of the school system.

One problem that must be considered in this regard is the effect of the proposed change on other outputs. For example, how does the change affect students' attitudes, health habits, and vocational development? Consider Goal I: Self Concept. Table 6-5 indicates that the reduction in teacher load might, again, lead to improvement in self concept; however, a reduction in the average educational level of the teachers is likely to result in an opposite effect. Since the latter coefficient is not statistically significant (see Appendix Table A-5), one might conclude that the overall effect of the proposed change on self concept is probably positive, but the need to assess the impact of the reduction in the average educational level of the teachers remains. Moreover, an inspection of Table 6-6, for example, reveals that a reduction in the teaching load might reduce the score on Goal II: Understanding Others. A similar effect is shown for the reduction in salary for several outputs. The implication of all this is that the school decision maker must weigh the benefits from a change in one output (such as verbal skills) against losses in other outputs (such as understanding others). The decision may not be simple or easy to make, but consistent results of the type presented here would go a long way in enabling school management personnel to make better decisions.

Other Management Implications

The results suggest several implications for management that do not require either new or realigned resources. For example, the use of innovative practices by teachers could enhance output, as could changes in teacher satisfaction and values. It is observed that greater use of innovative practices (INNOVATE) and greater teacher job satisfaction (TSATISF) are likely to increase the score on Goal X: Preparation for a Changing World. Another example is the coefficient of REACTL (-0.277) indicating a lower score on Goal VIII: Vocational Development, as more teachers perceive professional recognition to be achieved through personal relationships (such as rapport with central office or immediate supervisor) rather than quality and quantity of work completed. Finally, the results suggest districtwide implications regarding such matters as desirable teacher characteristics, use of guidance personnel, auxiliary manpower, extracurricular expenditures, paraprofessional support, or library resources.

Prediction

The main purpose of the data collection activities of the Division of Educational Quality Assessment (DEQA) in the Pennsylvania Department of Education is to enable schools to determine the extent to which they achieve an output level consistent with their input levels. If there are n schools in the system, then we compute for each school

$$\hat{Y}_i = a_0 + a_1 X_{1i} + a_2 X_{2i} + \ldots + a_k X_{ki}, \qquad (i = 1, n) \qquad (6\text{-}2)$$

where Y_i is the predicted level of the output, Y, for the ith school; a_0, a_1, $\ldots, a_k$ are the k regression coefficients for the production function of Y taken from the reduced form coefficients reported in Appendix Table A-5; and X_{ji} is the level of the jth input observed in the ith school.

The main thrust of the DEQA analysis is that schools with different input levels ought to expect different output levels. Hence Y would depend on the levels of student, community, school, and instructional staff inputs. The School Report, sent to participating schools by the DEQA, contains predictions for each school for each of the outputs, along with a prediction interval (given by $\hat{Y} \pm SEE$).[f] The position of the actual school score (Y) is also noted. To the extent that Y is within the prediction interval, the implication is that the school is doing approximately as it should. Similarly, if Y is less than $Y - SEE$, the school is apparently less productive than it should be, and some remedial action is recommended (Burson, 1972).

CONCLUDING COMMENTS

The Pennsylvania data provide a number of insights for school management personnel. Properly interpreted, the results should be quite useful. At the same time it must be recognized that both the data and the analysis are less than ideal, so that management decisions should not rely exclusively on the data presented here. Moreover, the equation systems reported in this chapter provide only partial information to decision makers. The analysis does not permit an examination of the effect of various inputs on the *overall* level of output. The next chapter presents a model that attempts to overcome this difficulty.

[f] SEE = standard error of estimate.

Chapter Seven

An Output Index: Canonical Correlations

The analysis of the preceding chapter provides a limited use of input-output analysis for educational management because the regression coefficients indicate the expected change in any one output due to changes in one or more inputs, but not in the overall level of educational output. An index of output that takes into account all the outputs could be used to overcome this problem. In addition, an overall output index is necessary for a number of applications, including an analysis of economies of scale in secondary schools, and for the development of a teacher salary plan based upon the production function concept. The output indexes presented in this chapter are based upon the canonical correlation technique.[a]

CANONICAL CORRELATIONS

The technique of canonical correlation is designed to assess the degree of association between two *sets* of variables. Let one of these sets be denoted by $Y_1, Y_2, \ldots, Y_n$ and the second set by $X_1, X_2, \ldots, X_m$. In the canonical correlation analysis, a canonical correlation coefficient is computed such that the correlation between the weighted sum of the Y's, given by

$$\sum_{i=1}^{n} w_i Y_i,$$

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[a] One study that utilized canonical correlations for educational input-output analysis is Moats (1970). That study, however, did not consider the utilization of the technique for developing an educational output index. For a discussion of the methodologies of and studies on canonical correlations consult Chow (1964), Hooper (1969), Hu (1972), Johnston (1972), pp. 331-334; Tintner (1946), and Waugh (1942).

and the weighted sum of the X's, given by

$$\sum_{j=1}^{m} v_j X_j,$$

is maximized. Of interest in the present analysis are not so much the canonical correlation coefficients, but rather the weights, w_i, which are associated with the maximum canonical correlation.

In the present context the set of the Y's would represent the outputs and the set of the X's the inputs. Thus the w's are the canonical output weights and the v's are the respective input weights. To the extent that one could assume that outputs are the outcomes of the inputs, the output weights indicate the relative importance of each of the outputs as exhibited by the input-output data. This may be a product of some conscious management decisions on the part of school administrators, or it could result from the interplay of forces beyond the control of school administrators (when nonmanipulative inputs are also included in the input set). Consequently, it would not be surprising if the weights produced by the canonical correlation technique conflict with the weights that some administrators believe should be assigned to the outputs.

Once output weights are obtained, an output index could be computed according to:

$$Q^* = \sum_{i=1}^{n} w_i^2 Q_i \tag{7-1}$$

where Q^* is the output index, and w_i^2 is the squared canonical weight associated with the ith output, Q_i. Q^* could then be computed for each school, and analyses utilizing such an index may take place.

OUTPUT INDEXES

The Pennsylvania data have been utilized to derive a number of output indexes. The indexes differ from one another according to the sets of input and output variables that are included in the canonical correlation analysis. Table 7-1 provides a list of outputs and inputs included in each of the canonical analyses.

The first and second canonical analyses differ only in that the variable HOLDING was included in the second, but not in the first, analysis. That variable

Table 7–1. Input and Output Variables Included in the Canonical Correlation Analyses

Set 1.	*Outputs:*	Goals I through X (12 outputs)
	Inputs:	FAMSES, TSALARY, ADA, CUG, PRCO, TLOD, CSIZ, AEE, BRAT, AMAN, AXMAN, SFRAT, PSUP (13 inputs)
Set 2.	*Outputs:*	Goals I through X, and HOLDING (13 outputs)
	Inputs:	Same as for Set 1.
Set 3.	*Outputs:*	Goals I through X (12 outputs)
	Inputs:	Same as for Set 1 plus the following: SEX, LOCATION, RACE, LIBRARY, MORESB, MORESG, VALUES, FOCC, MOCC, PCTMW, TPPOS, TLOCALE, TCOLLEGE, TSTABL, TMEDUC, REACTL, RECIDEA, TCAREER, TSATISF, DISCREP, CLPRACT, TEXPER, TEDUC, EFFORT, HOUSING, STAFFP, BOOKSP, GUIDANCE, INNOVATE (43 inputs)
Set 4.	*Outputs:*	Goals I through X (12 outputs)
	Inputs:	SEX, INTERRAC, LOCATION, RACE, LIBRARY, COUNSEL, MORESB, MORESG, VALUES, ATTEND, PCTMW, TAGE, TPPOS, TLOCALE, TCOLLEGE, TSTABL, TMEDUC, TFOCC, REACTL, RECIDEA, TCAREER, TSATISF, DISCREP, CLPRACT, TEXPER, TEDUC, TSEX, SUBSIDY, INSEXADM, EFFORT, HOUSING, BOOKSP, GUIDANCE, INNOVATE, plus inputs used in Set 1 (47 inputs)

Note: For a brief description of the acronyms consult the Glossary. Additional information is provided in Table 6–4 and Appendix Tables A–1 through A–4. See also Russell (1971) or Kuhns (1972).

has been included in the input set by Kuhns. However, it appears that HOLDING represents an output of the educational system, indicating the degree to which the system has been successful in retaining students.[b] The two canonical analyses are intended to provide a comparison between the resulting output indexes and to indicate the effect of changing the output mix from twelve to thirteen variables.

The third and fourth canonical analyses likewise provide a descriptive test of the canonical output weights and resulting output indexes to changes in the sets of inputs included in the respective canonical analyses. Thus, while both the third and fourth analyses contain the same output sets as the first analysis, the number of input variables increases from thirteen to 42 for the third run and to 47 input variables for the final run.

We note that the inputs in the first canonical analysis comprise mainly manipulative variables. The input set included in the third run was chosen on the basis of a somewhat revised list of variables entering into the single-equation

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[b] For a similar argument, see Burkhead, Fox, and Holland (1967), where a similar variable was regarded as an output variable in the analysis.

Table 7-2. Normalized Canonical Weights for Various Input-Output Sets

Outputs	*Set 1*	*Set 2*	*Set 3*	*Set 4*
Goal I	0.108	0.130	−0.158	0.080
Goal II	0.446	0.382	0.097	0.309
Goal III-v	0.497	0.470	−0.026	0.355
Goal III-m	0.099	0.145	−0.468	−0.603
Goal IV	0.241	0.237	0.141	−0.126
Goal V	−0.525	−0.502	−0.444	0.368
Goal VI	−0.156	−0.139	0.090	−0.351
Goal VII-p	0.068	0.133	0.181	0.108
Goal VII-o	−0.140	−0.091	−0.589	−0.237
Goal VIII	0.303	0.328	0.212	0.227
Goal IX	0.068	0.051	0.022	−0.038
Goal X	−0.233	−0.317	0.310	−0.113
HOLDING	a	−0.175	a	a

[a] This output was not included in the output set.

model developed by Kuhns, whereas the input set included in the final canonical analysis contains all the input variables in the data set, with the exception of inputs that appear to be proxies for outputs (OCDESIRE, OCEXPECT, POSTGRAD, and HOLDING) and inputs that are highly correlated with other inputs in the same set.

The normalized canonical weights for the outputs in each of the analyses are reported in Table 7-2.[c] One is immediately struck by the considerable variation among the sets of weights, although the variation between the first and second sets is relatively small. It should be noted, however, that the output indexes are based on the squares of the canonical coefficients (w_i^2); hence, a shift in sign but not in absolute value of a weight between successive canonical analyses would have no effect on the output index. Moreover, even if the various sets of weights are substantially different from one another, it is still possible that the output indexes would be highly correlated, so that in practice it would not make much difference which of the sets was chosen for the development of the output index.

Table 7-3 provides an illustration of the manner by which the output index is computed from the canonical weights for a particular school (School A). The levels of the twelve outputs in that school are given in the first column (Q_i). In the second column, the squared canonical weights for the fourth canonical analysis are provided (w_i^2). The third (rightmost) column represents the contribution of each of the outputs to the total output index, measured by the product of the squared canonical weight and the respective output level ($Q_i \cdot w_i^2$). The

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[c] The canonical correlation *coefficients* are all very close to 1 and are highly significant.

Table 7-3. Calculation of an Output Index: An Illustration for "School A"

Goal	*Value of Goal in School A* (Q_i)	*Canonical Weight* (w_i^2)	*Contribution of Goal to Output Factor in School A* ($Q_i{*}w_i^2$)
I	89.45	.006400	.5726
II	91.05	.095481	8.6935
III-v	15.52	.126025	1.9559
III-m	18.71	.363609	6.8031
IV	94.62	.015876	1.5022
V	170.81	.135424	23.1318
VI	122.74	.123201	15.1217
VII-p	60.72	.011664	.7082
VII-o	137.21	.056169	7.7069
VIII	84.02	.051529	4.3295
IX	156.47	.001444	.2259
X	109.33	.012769	1.3960
		Output Factor ($\Sigma w_i^2 Q_i$)	= 72.1472

overall output level is given by the sum of the contributions of the output factors (72.1472 for School A).

The same procedure was employed to derive output levels for each of the 53 Pennsylvania schools on the basis of the four sets of canonical weights. To test the consistency of the four output indexes, the correlations among the four indexes were computed and are reproduced in Table 7-4. The output indexes were also correlated with an alternative measure of output—the sum of the verbal and mathematical scores (Goal III-v + Goal III-m)—to see whether an output index based on a number of educational output dimensions differs from the traditional measure of basic skills as the sole index of educational output.

The results of the correlational analysis in Table 7-4 are inconclusive. On the one hand a high correlation is found among the first, second, and fourth indexes. For reasons not yet clearly understood, the third output index is not as highly

Table 7-4. Zero Order Correlation Coefficients for Output Indexes

	Index 1	*Index 2*	*Index 3*	*Index 4*	*Sum of Verbal and Math Scores*
Index 1	1.0000				
Index 2	0.9924	1.0000			
Index 3	0.6492	0.6449	1.0000		
Index 4	0.9086	0.9180	0.6372	1.0000	
Sum of Verbal and Math Scores	0.4257	0.4576	0.3093	0.7290	1.0000

correlated with the others as one would desire if it can be argued that the canonical correlation technique provides output indexes that are relatively insensitive to changes in the set of inputs. Apparently, the addition of 29 input variables does change the output index to a considerable extent. However, the fourth index, based on 47 input variables, is highly correlated with the first and second indexes. Also, the addition of the output HOLDING does not apear to affect the output index much (compare indexes 1 and 2).

In addition, the correlations between the basic skills score and the output indexes are relatively low. Even the highest correlation (between the basic skills index and the fourth canonical index [$r = 0.729$] is not very high; a regression analysis, with the basic skills score as the independent variable and the fourth output index as the dependent variable, indicates that in many cases the predicted output is much different from the actual score, so that the rank ordering of many schools differs considerably in the two cases. This is exactly why it is considered necessary to include other outputs in the analysis, and the results reported herein support that position.[d]

APPLICATIONS INVOLVING THE OUTPUT INDEX

Although there would be numerous opportunities to utilize the output index, the present analysis will be confined to two applications with reference to a third.

Economies of Scale

One area in which considerable research has been undertaken in recent years is economies of scale in school operations.[e] The research has been hampered, however, by the lack of a comprehensive output measure that must be used in the analysis to take account of varying educational qualities. Since the methodology used to determine scale effects has been developed and fully discussed elsewhere, there is no need to repeat it here.

Suppose that the school is the proper unit for analyzing scale effects. If a parabolic relationship is assumed between the cost and size variables, then the equation which one seeks to estimate would resemble the following:

$$C = a + bS + cS^2 + dQ + eP + u \tag{7-2}$$

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[d] A similar regression analysis for the canonical indexes indicates that the first, second, and fourth indexes are very good predictors of one another; this is not true for the third index.

[e] See, for example, Cohn (1968), Cohn and Hu (1973), Hettich (1968), Hirsch (1959, 1960), Riew (1966), and Sabulao and Hickrod (1971).

where C is per pupil cost, S is school size, Q is the overall output measure, P is an index of the prices that the schools must pay for various services, and u is a stochastic error term. It is not necessary to include variables measuring differences in socioeconomic conditions because they should not affect the cost of education unless educational quality is affected, and educational quality is included as a variable in the equation. P is included to adjust for cost variations among schools that are due strictly to differences in cost-of-living conditions across the state.

It has also been argued that a hyperbolic cost function might be more appropriate (Cohn, 1968, and Cohn and Hu, 1973), in which case the equation to be estimated is given by:

$$C = a + b(1/S) + cQ + dP + u \tag{7-3}$$

Empirical Results. The fourth canonical output index was utilized as a proxy for Q (because it is based on the largest number of input variables). Although a comprehensive measure of cost is lacking, information is available on the variable INSEXADM (instructional expenditures per pupil in average daily membership) for the Pennsylvania data. Use of this variable will certainly limit the extent of scale economies shown by the data, but the main purpose of the analysis is to illustrate the uses of the output index. Also, average teacher salary (TSALARY) has been used to represent P because most instructional costs are a direct result of teacher compensation.

Table 7-5 provides the regression results for equations (7-2) and (7-3). The

Table 7-5. Regression Results for Economies of Scale Model (Dependent Variable = INSEXADM)

Explanatory Variables	*Parabolic Function*		*Hyperbolic Function*	
	b	*t*	*b*	*t*
Output (Q)	0.9048	0.195	0.952	0.207
TSALARY (P)	0.0178	1.547	0.0179	1.538
ENROLL (S)	-0.0168	0.0341		
ENROLL^2 (S^2)	0.00000115	0.062		
1/ENROLL (1/S)			9550.7617	0.777
R^2	0.06		0.056	
R_c^2	0.00		0.00	
F	0.77		0.96	
SEE	41.23		40.91	

Notes: b = partial regression coefficient

t = t-ratio

R_c^2 = coefficient of determination corrected for degrees of freedom

SEE = standard error of estimate

empirical results are clearly disappointing. First, none of the regression coefficients is statistically significant, and it appears also that all the variables taken together do not contribute significantly toward the reduction in the variance of *INSEXADM.*[f] Despite this, the signs of the coefficients are consistent with a priori expectations. Further analysis utilizing both different data and different cost measures might prove more rewarding.

Evaluation of the Contribution of Teacher Characteristics

It is well known that teacher salaries are typically based on the so-called single salary schedule, where individual teacher salaries are only a function of teaching experience and educational attainment (Cohn, 1972, Chapter 9; Benson, 1968, Chapter 10). It has been argued elsewhere (Cohn, 1972, pp. 293-297, and Cohn, 1973) in favor of a salary program that would take into account those factors that appear to influence educational output, so that teachers possessing those attributes which, on the average, are shown to enhance educational output would be rewarded in proportion to the production function coefficients. For example, if a unit of teaching experience is shown to increase output by an average amount of 1 percent, a teacher possessing one unit of experience greater than the average for the sample under study would be paid an increment in salary proportional to the 1 percent improvement in output. Such a salary policy would encourage teachers to acquire the attributes for which a monetary reward is offered and would serve to reduce the gap between salary payments and relative productivity levels of teachers.

Again, the model proposed here is not intended as the ideal framework for measuring the contribution of teacher characteristics but rather serves as an example. The equation to be estimated is given by:

$$Q = a + b_1\ TCOLLEGE + b_2 TEXPER + b_3 TEDUC + \sum_{i=1}^{k} FAC\,i + u \qquad (7\text{-}4)$$

Where Q is the overall output measure; $FAC\,i$ is the ith factor accounting for student, community, school, and teacher inputs not explicitly included in the equation; and u is a stochastic error term. The model would assess the contribution to total output (Q) of educational preparation, teaching experience, and type of college from which the teacher graduated.

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[f] It should be noted, however, that, except for *ENROLL*, all of the variables included in the model have very low coefficients of variation (0.096 for *INSEXADM*, 0.068 for *TSALARY*, and 0.018 for the output index).

Table 7-6. Regression Results for Teacher Characteristics Model (Dependent Variable = Fourth Output Index [Q])

Explanatory Variable	*Partial Regression Coefficient*	*t-Ratio*
TCOLLEGE	−0.0582	0.042
TEXPER	0.0067	0.083
TEDUC	0.1520	0.229
FAC 1	0.2348	1.234
FAC 2	0.1149	0.555
FAC 3	−0.6956	4.154
FAC 4	−0.2617	1.731
FAC 5	0.1829	1.180
R^2	0.405	
R_c^2	0.297	
F	3.743	
SEE	1.085	

Notes: R_c^2 = coefficient of determination corrected for degrees of freedom
SEE = standard error of estimate

Empirical Results. Estimates for the three teacher characteristics were obtained on the basis of the inclusion of eleven factors and five factors (other than those explicitly included in the equation), respectively. Since the addition of six factors did not contribute significantly to the explanatory power of the model, only the equation with the five factors (k=5) is reported in Table 7-6.[g] The results indicate that none of the teacher characteristics has a statistically significant coefficient. This is particularly revealing with regard to *TEXPER* and *TEDUC*, because the results conflict with accepted opinion that experience and educational preparation should be rewarded.

Note, however, that the output variable has an extremely low coefficient of variation (0.018), indicating that the 53 Pennsylvania schools utilized in this analysis are quite similar in their educational output. The same is also true of *TCOLLEGE* and *TEDUC* (with coefficients of variation of 0.053 and 0.067, respectively), but not of *TEXPER* (with a coefficient of variation of 0.243). One would have to examine additional evidence before the present assumption regarding the contribution to output of educational preparation and experience could be dismissed.

Output Inventives in State Aid to Education

It has been proposed (Cohn, 1974, Chapter 7) that the state aid formula should include incentives for schools to increase their productivity. A prerequisite for such a framework would be the development of an output index that can be shown to be consistent over time. The present analysis provides the nucleus for further development and testing of the output index over time and space.

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[g] The five factors are principle components of 48 inputs. The five factors account for approximately 50 percent of the variance in the input set they represent.

CONCLUDING COMMENTS

The development of the output indexes was shown to provide several possibilities for future application. Although the present empirical results are very disappointing, the framework offers new possibilities that should be helpful in future research.

It has been noted that the output indexes are not very sensitive to changes in the output set utilized in the canonical correlation analysis. They are, however, sensitive to changes in the input set. Also, the output indexes may not be consistent over time and space, and one would need to study them with great care before serious conclusions are drawn.

Finally, one should not be satisfied with the canonical correlation method as the single framework for obtaining output indexes. Alternative approaches should be devised and comparisons among the resulting indexes should be made to ascertain that the output index used for management purposes is as sound as can be.

Chapter Eight

Mathematical Programming: An Alternative Input-Output Tool

The analysis of the preceding chapters has been cast almost exclusively in terms of marginal changes in the manipulative inputs based upon regression estimates of the production function coefficients. Further, the regression analysis only describes the educational production process, and does not explicitly account for managerial objectives and constraints.

Mathematical programming provides the basis for modeling the decision process relative to such objectives and constraints. It permits identification of those instruments that can be employed to attain specific targets. The most widely used programming technique is known as linear programming. As we shall see in the next section, the technique most useful for our purposes is not linear but rather goal programming. A brief description of the two is provided in the next section, followed by a discussion of how goal programming might be relevant in educational input-output analysis.

It should be pointed out that mathematical programming includes many other types of programming—including, for instance, recursive programming, quadratic programming, and a host of other models. A description of all such models is clearly outside the scope of this volume, and ample literature exists for the interested reader.[a]

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[a] There are numerous works on the method and application of linear programming. A nonmathematical approach is given in Dorfman (1953). More technical descriptions are contained in Baumol (1972), Chapter 5; Charnes and Cooper (1961); Dorfman, Samuelson, and Solow (1958); and Wagner (1969). Some intermediate texts in microeconomic theory now contain chapters on linear programming. See, for example, Ferguson (1972), Chapter 12; and Hibdon (1969), Chapter 10.

Goal programming is described in Charnes and Cooper (1961), and Ijiri (1965). Other types of mathematical programming include integer programming, nonlinear programming, and recursive programming. References for these techniques include Baumol (1972), Chapters 7-8; Sengupta and Fox (1969); and Wagner (1969).

LINEAR AND GOAL PROGRAMMING: AN INTRODUCTION

Linear Programming

Linear programming is a mathematical technique for solving problems in which the decision maker wishes to find the course of action that will maximize some linear objective function within certain constraints. These constraints are also in linear forms. A linear programming problem may be formulated as follows:

Maximize

$$c_1 x_1 + c_2 x_2 + \ldots + c_n x_n \tag{8-1}$$

subject to

$$\begin{aligned} &a_{11} x_1 + a_{12} x_2 + \ldots + a_{1n} x_n \leqslant b_1 \\ &a_{21} x_1 + a_{22} x_2 + \ldots + a_{2n} x_n \leqslant b_2 \\ &\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\ &a_{m1} x_1 + a_{m2} x_2 + \ldots + a_{mn} x_n \leqslant b_m \\ &x_1, x_2, \ldots, x_n \geqslant 0 \end{aligned} \tag{8-2}$$

where x_j $(j = 1, 2, \ldots, n)$ is the level of activity j, whereas the c's, a's, and b's are constants.

In the above formulation, the decision maker is seeking the set of values for the x's which will make the objective function in (8–1) a maximum while satisfying all the constraints in (8–2).

Minimizing the expression $(d_1 x_1 + d_2 x_2 + \ldots + d_n x_n)$ is the same as maximizing the expression $[-(d_1 x_1 + d_2 x_2 + \ldots + d_n x_n)]$ or maximizing $(c_1 x_1 + c_2 x_2 + \ldots + c_n x_n)$ where $c_j = -d_j$ $(j = 1, 2, \ldots, n)$. Also, $g(x_1, x_2, \ldots, x_n) \geqslant b$ where $g(x_1, x_2, \ldots, x_n)$ denotes a function of the n x variables can be written as $-g(x_1, x_2, \ldots, x_n) \leqslant -b$. Therefore, a problem such as:

Minimize:

$$d_1 x_1 + d_2 x_2 + \ldots + d_n x_n$$

subject to

$$a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n \geqslant b_1$$

$$a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n \geqslant b_2$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$

$$a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n \geqslant b_m$$

$$x_1, x_2, \ldots, x_n \geqslant 0$$

can be put into the format of (8-1) and (8-2) above.

Goal Programming

Goal programming is a special type of linear programming. In linear programming only one goal can be incorporated into the objective function to be maximized or minimized. In goal programming more than one goal can be incorporated into the objective function. Environmental conditions such as resource availability are put as constraints. Each goal is set at a level desired by the decision maker. This level need not be the best possible one, and it may or may not be attainable due to the limitations of available resources. Goal programming will provide the set of x values that satisfied the constraints and comes closest to the targets of the decision maker as represented by the stipulated levels of the different goals. The general form of a goal programming problem may be stated as follows:

Minimize

$$d_1^+ + d_1^- + d_2^+ + d_2^- + \ldots + d_m^+ + d_m^- \tag{8-3}$$

subject to

$$a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n + d_1^- - d_1^+ = g_1 \tag{8-4}$$

$$a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n + d_2^- - d_2^+ = g_2$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$

$$a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n + d_m^- - d_m^+ = g_m$$

$$a_{m+1,1}x_1 + a_{m+1,2}x_2 + \ldots + a_{m+1,n}x_n \leqslant b_{m+1} \qquad (8\text{-}5)$$

$$a_{m+2,1}x_1 + a_{m+2,2}x_2 + \ldots + a_{m+2,n}x_n \leqslant b_{m+2}$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$

$$a_{l1}x_1 + a_{l2}x_2 + \ldots + a_{ln}x_n \leqslant b_l$$

$$x_1, x_2, \ldots, x_n \geqslant 0 \qquad (8\text{-}6)$$

$$d_1^+, d_1^-, d_2^+, d_2^-, \ldots, d_m^+, d_m^- \geqslant 0 \qquad (8\text{-}7)$$

where

d_i^+ $(i = 1, 2, \ldots, n)$ = overachievement of goal i,

d_i^- $(i = 1, 2, \ldots, n)$ = underachievement of goal i,

the a's and b's are constants,

g_i $(i = 1, 2, \ldots, n)$ = target level of goal i,

and x_i $(i = 1, \ldots, n)$ are resource inputs.

In the above formulation the decision maker is seeking the set of x values that will minimize the objective function in (8-3) while satisfying the conditions in (8-4) through (8-7). If the decision maker wishes to attain as close as possible that particular level of goal i as represented by g_i, but is indifferent between over- and underachievement of this goal, then both d_i^+ and d_i^- will appear in the objective function (8-3). If, however, overachievement of goal i were acceptable to him, d_i^+ would not appear in the objective function whereas d_i^- would. Similarly if underachievement of goal i were acceptable, d_i^- would be eliminated from the objective function. The production function for the m different goals are presented in the m equations (8-4) and the resources available are represented by the environmental constraints (8-5).

If the decision maker wishes to attach different priorities to the different goals, he may do so by modifying the objective function (8-3). Consider the folflowing objective function:

Minimize

$$P_1 d_1^+ + P_1 d_1^- + 2P_2 d_2^- + P_2 d_3^+ \tag{8-8}$$

where

P_1 and P_2 are constants and

$P_1 >>> P_2$.

$P_1 >>> P_2$ means that P_1 is so much larger than P_2 that no number k can make $kP_2 \geqslant P_1$. In this case, the decision maker gives absolute priority to goal *1*. After goal *1* has been achieved, goals *2* and *3* are to be met under the criterion that goal *2* is twice as important as goal *3*. Once again, the presence of both d_1^+ and d_1^- in the objective function means that the decision maker wants to attain the target level of goal *1* but is indifferent between over- and underachievement of this goal. Overachievement of goal *2* and underachievement of goal *3* are acceptable as indicated by the absence of d_2^+ and d_3^- in the objective function.

Linear programming and goal programming problems can be solved by hand, using the simplex method or some variations of it. However, computer programs are ordinarily available as an integral part of most computer library packages, and these programs can handle problems that would be too tedious a task for hand computation.

GOAL PROGRAMMING IN EDUCATIONAL INPUT-OUTPUT ANALYSIS

Goal programming is particularly suitable as a technique for determining the best possible mix of resources in a school system. Education is a process that attempts to achieve multiple goals. These goals are so varied in nature that, despite our own efforts, we must conclude that there is as yet no satisfactory common basis for measurement.[b]

The following model is suggested as a possible solution to the problem of efficient resource allocation in a school system:

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[b] It has been argued that the differential lifetime earnings due to education might be used as a proxy for total output. Such a proxy measures only the investment value of education, not its consumption value, and moreover, it neglects external benefits and nonpecuniary benefits of education. For examples of the use of such a proxy see Holtmann (1968); and Plessner, Fox, and Sanyal (1968). The consumption-investment issue is described in detail in Cohn (1972), especially Chapters 5 and 7.

Minimize

$$d_1^- + d_2^- + \ldots + d_l^- \tag{8-9}$$

subject to

$$\begin{aligned} a_{11} x_1 + a_{12} x_2 + \ldots + a_{1m} x_m - d_1^+ + d_1^- &= g_1 - c_1 \\ a_{21} x_1 + a_{22} x_2 + \ldots + a_{2m} x_m - d_2^+ + d_2^- &= g_2 - c_2 \\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots & \\ a_{l1} x_1 + a_{l2} x_2 + \ldots + a_{lm} x_m - d_l^+ + d_l^- &= g_l - c_l \end{aligned} \tag{8-10}$$

$$x_j \leqslant h_j \tag{8-11}$$

$$x_j, d_i^+, d_i^- \geqslant 0 \qquad \begin{matrix} i = 1, 2, \ldots, l \\ j = 1, 2, \ldots, m \end{matrix} \tag{8-12}$$

where

d_i^+ = overachievement of goal i,

d_i^- = underachievement of goal i,

a_{ij} are the reduced form coefficients for the manipulative inputs such as we derived in Appendix Table A-5,

g_i = target level of goal i,

x_j = manipulative input j,

h_j = availability of input j,

c_i $= b_{il} y_1 + b_{i2} y_2 + \ldots + b_{in} y_n$ representing the contribution to goal i of the nonmanipulative inputs $y_1, \ldots, y_n$, where b_{ik} are the reduced form coefficients for the nonmanipulative inputs, also presented in Appendix A-5,

l = number of goals,

m = number of manipulative inputs

The right-hand side of each of the goal constraints in (8-10) is the difference between the target level of each goal and the contribution to the same goal by those nonmanipulative inputs. Constraints in (8-11) are the environmental constraints that represent the resources available. The objective function in (8-9) means that overachievement of each goal is acceptable while trying to achieve the different target levels of the goals.

In the context of our preceding analysis of the Pennsylvania data, some empirical analysis could have been presented using the technique of goal programming. We shall not, however, present any such results here, for two reasons. First, the technique of goal programming is particularly suitable for implementation at the district level. The regression coefficients presented in Appendix Table A-5 would be relevant only to the extent that the production function of the various schools are approximately equal. To ascertain the truth of such an assertion would require additional knowledge of the schools, which is strictly impossible due to the fact that the identification of the individual schools is precluded by the anonymity of the data. Second, there is considerable difference between a conclusion that marginal changes in some of the variables are likely to increase school productivity and a conclusion that a given vector of manipulative variables—including, perhaps, substantial changes from the status quo—should be sought.

What we are saying, in effect, is that whereas the goal programming technique is quite powerful and extremely useful in the present context, we are not certain that the reliability and accuracy of the production function estimates is such that large, finite changes in the manipulative variables should be made on this basis. It is clear, however, that consistent validation and replication of the results would in the not-too-distant future permit the type of analysis in education that is so commonplace in agriculture and other industries.

CONCLUDING COMMENTS

When reliable production function coefficients become available, it will be possible to employ goal programming in a flexible manner to determine the proper mix of manipulative inputs. It would, of course, be necessary to specify the desired levels of each goal—a requirement that may be rather distasteful to some educational administrators. At the same time, the goal programming approach may be repeated several times to test the sensitivity of the solution vector to changes in the program's format.

It is important to note that the utilization of programming models requires knowledge of the educational production function. Unless and until such production functions can be estimated with a reasonable degree of accuracy, our ability to formulate and employ sophisticated and powerful input-output techniques will be forestalled.

Although we have provided only a skeleton of the goal programming technique, it is clear that it holds great promise in the area of educational input-output analysis. Empirical work in this area would be of great interest.

Appendix Tables

Table A-1. Dimensions and Measurement of the EQA Goals (Grade 11)

Goal	*Range of Scores Possible*	*Dimensions*	*Measurement*
I	54–108	1. Control of environment 2. Personal attributes 3. Achieving in school 4. Relating to others	The Goal I inventory contains 54 items. Forty-seven of the items are from the Self-Esteem Inventory (Coopersmith, 1967) and the remaining seven items are from the Equality of Educational Opportunity Survey (Coleman et al., 1966).
II	22–110	Appreciating others who differ	The Goal II inventory contains 25 items: sixteen items developed by the Educational Testing Service (ETS) and revised by EQA and nine items developed by EQA. Three of the EQA items were not scored for analysis because a substantial number of pupils either omitted them or gave multiple responses.
III	200–800	Words and numbers	Schools were asked to choose either the Stanford Achievement Test; High School Battery, Form W, or the Iowa Tests of Educational Development, Form X-4. A composite basic skills score was derived from the following subtests: *Stanford Achievement*: Reading; English; Numerical Competence; Mathematics–Part A *ITED*: Correctness and appropriateness of expression; Ability to do quantitative thinking; Ability to interpret social studies reading; Ability to interpret literary materials
IV	28–140	1. Attitude toward school assignments 2. Perception of the learning process 3. Perception of the school climate	The Goal IV inventory contains 28 items which were developed by ETS and later revised by EQA.
V	44–220	1. Personal responsibility attitudes 2. Initiative in advocating change 3. Personal responsibility applications 4. Concern for democratic principles	The Goal V inventory contains 44 items which were developed by the Bureau of Educational Research

VI	*75–150*	*Health knowledge*	The Goal VI inventory is the Health Behavior Inventory, published by California Test Bureau. The 75 items are designed to measure health habits in the following 10 areas: (1) personal health; (2) safety and first aid; (3) family health; (4) infection and disease; (5) mental health; (6) nutrition; (7) community health; (8) exercise, rest and recreation; (9) drinking, smoking, and narcotics; and (10) dental health.
VII-p	20–100	1. Self-ratings of creative tendencies 2. Tolerance of ambiguity 3. Inner-directedness	The Creative Potential inventory contains 24 items developed by ETS and later revised by EQA. Four of the items were not scored for analysis because they correlated relatively low with the total score and did not discriminate between the highest scoring and lowest scoring groups.
VII-o	116–314	Creative output	Two inventories are used to measure in Goal VII. The Creative Output measure contains 116 items which were written by EQA based on a format developed by ETS.
VIII	50–100	1. Perception of work and the choice process 2. Involvement in the choice process 3. Judgment and independence in decision making 4. Preference for particular vocations aspects	The Goal VIII inventory is the Vocation Development Inventory Form IV (Crites, 1969). The inventory contains 50 items and all of the items are scored for analysis.
IX	77–210	1. Theater and art 2. Sports, politics, and science 3. Music	The Goal IX inventory contains 77 items which were developed by the Bureau of Educational Quality Assessment. The first three levels of the *Taxonomy of Educational Objectives: Affective Domain* (Krathwohl, Bloom, Masia, 1956) were used to guide the construction of items. In addition, the 11th grade inventory includes 21 knowledge items. Human accomplishments were divided into seven hypothesized dimensions.
X	29–145	1. Importance of education 2. Change in regulations 3. Change in school climate 4. Change in educational processes	The Goal X inventory contains 29 items which were developed by the Bureau of Educational Quality Assessment

Source: Adapted from Beers (1970).

Table A-2. EQA School and Community Inputs

Variable Name	*Measure*	*Weighting*	*Index Description*
STAFFP (Staff/pupil ratio)	The number of personnel who spend at least one-half their time in instructional activity was divided by the total number of students in the school		A higher value indicates more instructional personnel per pupil
BOOKSP (Books/pupil ratio)	The number of library books available for student checkout was divided by the total number of pupils in the school		A higher value indicates more library books available for each pupil
INNOVATE (School innovation)	The school administrator reported the extent to which his school employed 12+ relatively new educational practices (e.g., individual study, nongraded classes, instructional TV)	5 = Use regularly 4 = Use occasionally 3 = Considered trying 2 = Don't agree 1 = Never tried	A higher score on this index indicates the school uses several innovative practices regularly and/or many of the practices at least occasionally.
LIBRARY (Accessibility of library)	Students were asked how often they were able to use the school library	5 = Often as needed 4 = Frequently 3 = Several days a week 2 = Only when class is scheduled 1 = No library in school	A higher score on this index indicates that the school offers freer accessibility to its library resources
GUIDANCE (Counselor/ pupil ratio)	The number of secondary school personnel who devoted at least one-half their time to guidance activities was divided by the total number of students within the secondary school		A higher value indicates more guidance counselors per pupil

INSEXADM (Instructional expenses per ADM)	*The instructional expenses of the district were divided by the Average Daily Membership of the district.* All schools participating from district were assigned this score	*Expressed in whole dollars*	A higher value indicates that the school of interest is in a district that expends relatively more funds per pupil for instruction
EFFORT (Tax Effort Index)	Budgeted school taxes for the district were divided by the market values. All schools participating from district were assigned this score	Expressed in mills	A higher value indicates that the school of interest is in a district that has a greater willingness to tax itself for educational purposes
ENROLL (School enrollment)	The administrator reported the total school enrollment as of October 1 of a given year		The number indicates the building enrollment
HOLDING (Holding power)	Holding power was computed by the formula: (Graduating class + transfers – new students) ÷ (enrollment of same class beginning 10th grade)	The term transfers refers to those students who have left the sample school after beginning 10th grade to attend another school	A higher value indicates a relatively lower dropout rate

Source: Russell (1971), Table 1.

Table A-3. Instructional Staff Inputs

Variable Name	*Measure*	*Weighting*	*Index Description*
TMEDUC (Educational level of teacher's mother)	Sample teachers reported the highest level of formal education attained by their mother or female guardian	9 = Completed PhD or professional degree 8 = Some work toward PhD or professional degree 7 = Master's degree 6 = Graduated, college 5 = Some post-high school 4 = Graduated, high school 3 = Some secondary 2 = Elementary 1 = No formal education	A higher value on this index indicates that the mothers of the school's instructional staff have attained a higher level of formal education
TLOCALE (Teacher locale)	Sample teachers reported where they graduated from high school	5 = This town or immediate area 4 = In state but outside this town 3 = In another state 2 = In Puerto Rico or other U.S. possession 1 = In another country	A higher value on this index indicates that the school draws its instructional staff from the local area as opposed to other states or countries
TSTABL (Teacher stability)	Sample teachers reported the area in which they spent most of their lives	Response alternatives and respective weightings were identical to TLOCALE	A higher value on this index indicates that the school's instructional staff have spent most their lives in the immediate area as opposed to other states or countries
TCOLLEGE (Teacher's college)	Sample teachers reported whether or not they had earned a college degree and the type of college from which they graduated	3 = Liberal arts college or university 2 = State college 1 = No degree	A higher score on this index indicates that more of the staff have degrees and are more likely to have attended a liberal arts college or university than a state college

TEDUC (Teacher's education)	*The level of training of all teachers was obtained from the Professional Personnel Record*	9 = Doctor's degree 8 = Master's degree plus 2 years 7 = Master's degree plus 1 year 6 = Master's degree 5 = Bachelor's degree plus 1 year 4 = Bachelor's degree 3 = Three years of college 2 = Two years of college 1 = One year of college 0 = No college	A higher score on this index indicates that the school's instructional staff has a higher level of formal education
TEXPER (Teacher experience)	The total years of service in education was obtained for each teacher from the Professional Personnel Record		This number represents the mean educational experience, in years, of the school's instructional staff
TPPOS (Teacher present position)	Each sample teacher reported the number of years he had completed in his present position	8 = 20 or more years 7 = 16–20 years 6 = 11–15 years 5 = 6–10 years 4 = 3–5 years 3 = 2 years 2 = 1 year 1 = Less than 1 year	This index reflects the degree to which a school's instructional staff have remained in their present positions
TSALARY (Teacher salary)	The salary for each teacher was obtained from the Professional Personnel Record		This value represents the mean salary for a school's instructional staff
TSATISF (Teacher satisfaction)	Each sample teacher responded to a 6-item questionnaire which was scaled to reflect the degree of his satisfaction with his role in the school. (Example: "I find my job exciting and rewarding.")	5 = Almost always 4 = Frequently 3 = Sometimes 2 = Infrequently 1 = Almost never	A higher value on this index indicates a greater degree of job satisfaction of the school's instructional staff

Table A-3 continued

Variable Name	Measure	Weighting	Index Description
CLPRACT (Teacher classroom practices)	Each sample teacher reported the extent to which he employed 11 "innovative" classroom practices (e.g., pupil participation in lesson planning)	5 = Use regularly 4 = Use occasionally 3 = Considered its use 2 = Never use 1 = Don't agree with practice	The value on this index indicates the extent to which relatively innovative classroom practices are employed by the sample teachers
REACTL (Perception of actual characteristics influencing professional recognition)	From a list of 7 characteristics, the sample teacher chose the one he felt was *actually* most important in gaining professional recognition in his school district	7 = Rapport with central office 6 = Rapport with immediate supervisor 5 = Formal education 4 = Seniority 3 = Imaginativeness 2 = Dependability 1 = Quality and quantity of work	A higher value on this index indicates that the instructional staff perceives professional recognition to be achieved through personal relationships as opposed to quality and quantity of work completed
RECIDEA (Perception of "ideal" characteristics influencing professional recognition)	From a list of 7 characteristics, sample teachers chose the one they felt should *ideally* be most important in gaining professional recognition in their school district	Same codes were used as for REACTL	A higher value on this index indicates that the instructional staff feels that ideally professional recognition is obtained through personal relationships as opposed to quality and quantity of work completed

TCAREER (Teacher career)	*Sample teachers selected from 10 choices what they would like to be doing 5 years from now*	*10 = Will be retired* 9 = Teacher 8 = Special services 7 = Research worker 6 = Guidance 5 = Curriculum director 4 = Principal 3 = Administrator in central office 2 = Superintendent 1 = Out of education	A higher score on this index indicates that the career aspirations of the instructional staff tend toward classroom involvement
DISCREP (Discrepancy)	Sample teachers rated the relative influence 14 groups (superintendent, parents, teachers, etc.) had on the educational process. They then rated the *ideal* influence on each of those groups. For each of the 14 groups a real-ideal discrepancy was computed. A total discrepancy score was obtained: $D = \sqrt{\Sigma d^2}$	5 = Great deal 4 = Considerable 3 = Some 2 = Little 1 = None	A higher discrepancy score indicates a greater disparity between what the instructional staff sees as the actual and the ideal influences various groups have in determining educational matters in the school

Source: Russell (1971), Table 2

Table A-4. Additional Inputs

Variable Name	*Definition of Variable*
ADA	Average daily attendance for building
CUG	Curriculum unit/grade: total number of different subject matters available for student registration per grade
PRCO	Coefficient of preparation: the number of different subject matter preparations per week per academic teacher
TLOD	Teacher load: average academic teacher instructional hours per week. It does not include noncredit classes, i.e., study halls, clubs, etc.
CSIZ	Class size: average number of students per class
AEE	Extracurricular expenditures/student: total number of dollars spent in the school district for extracurricular activities per secondary student
BRAT	Crowding: the ratio of building enrollment to actual state rated capacity
AMAN	Administrative man hours per student: total number of secondary school personnel with administrative responsibilities (e.g., principals, assistant principals, attendance officers, department heads, etc.) multiplied by the lengths of the school day and the school year, and divided by the numbers of students enrolled in the building
AXMAN	Auxiliary man hours per student: total number of counselors, librarians, audiovisual personnel, etc., in the secondary school, multiplied by the lengths of the school day and year, and divided by building enrollment
SFRAT	Student to academic faculty ratio
PSUP	Paraprofessionals: sum of the hours worked in the school per week by all nonprofessional teacher aides including secretaries whose primary function is to aid classroom teachers

Source: Kuhns (1972), pp. 55–58.

Table A–5. Production Function Estimates for Pennsylvania Secondary Schools (Regression Coefficients and, in Paranthesis, Standard Errors)

	GOAL I			*GOAL II*			*GOAL III-v*			*GOAL III-m*		
Input	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*
	Structural	*Reduced Form*		*Structural*	*Reduced Form*		*Structural*	*Reduced Form*		*Structural*	*Reduced Form*	
Endogenous												
GOAL I							0.119 (0.140)			0.142 (0.198)		
GOAL II							0.032 (0.094)			0.039 (0.121)		
GOAL III-v	0.310 (0.309)			0.052 (0.295)						0.556 (0.204)		
GOAL III-m	0.080 (0.234)			0.020 (0.274)			0.427 (0.116)					
GOAL IV	0.013 (0.065)											
GOAL V												
GOAL VI	-0.054 (0.097)						0.024 (0.060)			-0.053 (0.088)		
GOAL VII-p	-0.055 (0.254)											
GOAL VII-o										-0.025 (0.328)		
GOAL VIII	0.643 (0.268)						-0.043 (0.217)					

Table A–5 continued

	GOAL I			*GOAL II*			*GOAL III-v*			*GOAL III-m*		
Input	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*
	Structural	*Reduced Form*		*Structural*	*Reduced Form*		*Structural*	*Reduced Form*		*Structural*	*Reduced Form*	
GOAL IX	0.085 (0.101)											
GOAL X												
Exogenous												
LIBRARY		0.376 (0.335)	1.312 (0.969)		0.039 (0.018)	-0.919 (1.088)		0.066 (0.115)	0.054 (0.964)		0.027 (0.137)	0.650 (1.213)
TPPOS		0.036 (0.089)	-1.025 (0.856)		0.0003 (0.002)	-1.118 (0.961)		0.006 (0.020)	-0.324 (0.852)		0.0004 (0.021)	-0.271 (1.072)
TCOLLEGE		-0.983 (0.903)	0.031 (1.833)	-1.324 (1.271)	-1.345 (1.292)	-3.330 (2.058)		-0.289 (0.304)	0.153 (1.824)		-0.301 (0.364)	2.549 (2.294)
TLOCALE		-0.292 (0.295)	2.669 (2.258)		-0.003 (0.014)	0.490 (2.536)		-0.051 (0.085)	-1.663 (2.248)		-0.027 (0.097)	-2.249 (2.827)
TSTABL		-0.002 (0.469)	0.306 (2.756)		-0.012 (0.012)	-4.362 (3.095)		-0.032 (0.110)	3.708 (2.744)		-0.009 (0.128)	2.313 (3.450)
TMEDUC		-0.210 (0.227)	0.405 (0.646)		-0.002 (0.009)	0.162 (0.725)		-0.024 (0.099)	0.585 (0.634)		-0.020 (0.125)	0.415 (0.809)
REACTL		-0.158 (0.137)	0.333 (0.376)		-0.001 (0.007)	0.197 (0.422)		-0.018 (0.073)	0.062 (0.374)		-0.015 (0.093)	0.141 (0.470)
RECIDEA		0.508 (0.494)	1.512 (0.730)		0.008 (0.029)	-0.304 (0.820)		0.107 (0.125)	0.693 (0.727)		0.107 (0.148)	0.397 (0.914)
TCAREER		0.055 (0.070)	-0.001 (0.337)		0.001 (0.003)	-0.058 (0.378)		0.012 (0.017)	-0.104 (0.335)		0.013 (0.020)	0.395 (0.421)

TSATISF		*0.065* *(0.066)*	*0.323* *(0.287)*		*0.001* *(0.003)*	*0.312* *(0.322)*		0.013 (0.018)	-0.275 (0.285)		0.009 (0.021)	0.183 (0.359)
DISCREP		-0.012 (0.028)	0.098 (0.520)	-0.324 (0.311)	-0.326 (0.312)	-0.469 (0.584)		-0.023 (0.052)	-0.177 (0.518)		-0.027 (0.063)	-0.167 (0.652)
CLPRACT		-0.030 (0.037)	-0.274 (0.150)		-0.001 (0.002)	-0.254 (0.169)		-0.006 (0.009)	-0.050 (0.150)		-0.007 (0.011)	-0.146 (0.188)
TSALARY		0.0005 (0.0003)	0.0008 (0.0006)	0.0002 (0.0003)	0.0002 (0.0003)	0.001 (0.001)	-0.008 (0.036)	0.0002 (0.0002)	0.001 (0.001)		0.0002 (0.0002)	0.0004 (0.001)
TEXPER		-0.061 (0.055)	0.064 (0.157)		-0.001 (0.005)	0.264 (0.177)		-0.001 (0.050)	-0.024 (0.157)		-0.013 (0.043)	0.059 (0.197)
TEDUC	0.508 (0.475)	0.904 (0.764)	0.056 (1.166)		0.013 (0.049)	-1.359 (1.309)		0.185 (0.206)	-1.093 (1.161)		0.177 (0.236)	-0.633 (1.459)
EFFORT	-0.014 (0.044)	-0.026 (0.072)	-0.059 (0.070)	-0.072 (0.045)	-0.073 (0.046)	-0.113 (0.078)		-0.010 (0.018)	0.029 (0.070)		-0.011 (0.020)	0.045 (0.088)
STAFFP		11.67 (14.00)	-15.863 (47.332)		1.426 (5.493)	-39.151 (53.145)	15.146 (16.183)	22.36 (23.55)	43.475 (47.116)		13.69 (15.13)	43.280 (59.249)
BOOKSP		-0.006 (0.008)	-0.132 (0.084)		-0.0001 (0.0004)	-0.020 (0.094)		-0.001 (0.002)	-0.036 (0.083)		-0.001 (0.002)	-0.073 (0.105)
GUIDANCE	57.389 (298.001)	110.3 (512.1)	1130.148 (569.182)		2.063 (11.20)	1081.558 (639.074)		26.60 (108.0)	-246.706 (566.580)		34.76 (114.6)	24.027 (712.480)
INNOVATE		0.006 (0.007)	0.055 (0.057)		0.001 (0.0003)	-0.003 (0.064)		0.001 (0.002)	0.065 (0.057)		0.001 (0.002)	0.037 (0.071)
ADA		0.0005 (0.0004)	-0.001 (0.001)	0.001 (0.001)	0.002 (0.0005)	0.00006 (0.001)	0.001 (0.0004)	0.001 (0.0005)	0.001 (0.001)		0.001 (0.0004)	0.001 (0.001)
CUG		-0.063 (0.028)	-0.017 (0.038)		-0.003 (0.012)	0.009 (0.043)	-0.008 (0.015)	-0.039 (0.022)	-0.027 (0.038)	-0.030 (0.021)	-0.053 (0.026)	-0.069 (0.048)
PRCO		3.576 (2.075)	1.596 (4.687)		0.028 (0.148)	-4.129 (5.262)		0.421 (1.459)	2.821 (4.666)	-0.115 (1.645)	0.292 (2.038)	3.590 (5.867)
TLOD	-0.046 (0.082)	-0.307 (0.096)	-0.233 (0.154)	0.157 (0.100)	0.141 (0.091)	0.002 (0.173)	-0.131 (0.067)	-0.245 (0.072)	-0.111 (0.153)	-0.046 (0.083)	-0.184 (0.086)	-0.137 (0.193)

Table A–5 continued

Input	*GOAL I*			*GOAL II*			*GOAL III-v*			*GOAL III-m*		
	Simultaneous System		*OLS*	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*
	Structural	*Reduced Form*		*Structural*	*Reduced Form*		*Structural*	*Reduced Form*		*Structural*	*Reduced Form*	
CSIZ	-0.008 (0.027)	-0.014 (0.041)	0.210 (0.086)	-0.040 (0.030)	-0.040 (0.030)	0.016 (0.097)		0.006 (0.011)	0.018 (0.086)		-0.006 (0.012)	0.040 (0.108)
AEE	-0.011 (0.007)	-0.007 (0.010)	-0.014 (0.015)	0.010 (0.010)	0.011 (0.010)	0.015 (0.017)	0.012 (0.005)	0.017 (0.007)	0.006 (0.015)	0.004 (0.007)	0.012 (0.009)	-0.009 (0.019)
BRAT		-0.001 (0.402)	-0.672 (0.992)	-1.161 (0.668)	-1.170 (0.662)	-2.108 (1.114)		-0.085 (0.274)	-0.024 (0.988)		-0.233 (0.337)	-0.700 (1.242)
AMAN	0.042 (0.094)	0.265 (0.127)	0.148 (0.147)		0.016 (0.057)	0.024 (0.165)	0.144 (0.052)	0.243 (0.079)	0.167 (0.146)		0.157 (0.079)	0.080 (0.184)
AXMAN	-0.121 (0.058)	-0.216 (0.076)	-0.131 (0.134)		-0.008 (0.027)	-0.100 (0.150)	-0.049 (0.043)	-0.113 (0.056)	-0.012 (0.134)	-0.005 (0.048)	-0.086 (0.066)	-0.052 (0.168)
SFRAT		-0.014 (0.028)	-0.177 (0.077)		-0.00001 (0.002)	0.029 (0.086)		-0.002 (0.011)	-0.001 (0.076)		0.004 (0.013)	-0.041 (0.096)
PSUP		-0.002 (0.002)	-0.002 (0.003)	-0.001 (0.002)	-0.001 (0.002)	0.005 (0.003)		-0.002 (0.001)	-0.003 (0.003)	-0.004 (0.002)	-0.005 (0.002)	-0.007 (0.004)
SEFAC 1	-0.039 (0.256)	0.155 (0.244)	-0.163 (0.423)	0.806 (0.267)	0.857 (0.196)	1.287 (0.475)	0.422 (0.140)	0.745 (0.182)	0.609 (0.421)	0.174 (0.242)	0.627 (0.219)	0.365 (0.529)
SEFAC 2	-0.378 (0.148)	-0.502 (0.171)	-0.268 (0.341)	0.237 (0.147)	0.232 (0.148)	0.458 (0.383)	-0.031 (0.108)	-0.097 (0.118)	-0.017 (0.339)	0.080 (0.155)	0.010 (0.145)	0.131 (0.427)
SEFAC 3	-0.146 (0.140)	-0.011 (0.185)	0.178 (0.238)	0.042 (0.183)	0.058 (0.267)	-0.076 (0.267)	0.066 (0.098)	0.205 (0.131)	0.374 (0.237)	0.219 (0.132)	0.308 (0.164)	0.464 (0.298)
SEFAC 4	-0.133 (0.151)	0.018 (0.170)	-0.015 (0.250)	0.047 (0.163)	0.059 (0.160)	-0.084 (0.281)	0.078 (0.105)	0.166 (0.120)	0.407 (0.249)	0.109 (0.139)	0.151 (0.147)	0.198 (0.313)

INTERCEPT	25.46 (18.670)	91.02 (4.938)	78.083 (18.174)	91.756 (6.534)	93.10 (4.586)	135.516 (20.406)	-3.935 (15.164)	18.23 (3.128)	7.592 (18.091)	3.153 (20.389)	20.44 (2.993)	6.193 (22.750)
R-SQUARE	0.733		0.824	0.577		0.797	0.850		0.816	0.695		0.688
F	4.759		2.278	3.070		1.906	11.627		2.160	5.617		1.070
SEE	0.709		1.015	0.931		1.139	0.518		1.010	0.711		1.270
Endogenous												
GOAL I	0.134 (0.411)						0.287 (0.484)			0.159 (0.178)		
GOAL II												
GOAL III-v							0.195 (0.554)					
GOAL III-m							-0.359 (0.441)					
GOAL IV				0.597 (0.196)			0.105 (0.161)					
GOAL V	0.174 (0.147)						0.081 (0.175)					
GOAL VI	0.121 (0.219)			-0.032 (0.244)								
GOAL VII-p												
GOAL VII-o				-0.269 (0.132)			-0.081 (0.136)			-0.003 (0.042)		
GOAL VIII				1.422 (0.742)			0.385 (0.626)			-0.031 (0.261)		
GOAL IX	0.308 (0.177)			0.332 (0.190)			-0.064 (0.196)			0.190 (0.062)		
										0.062 (0.066)		

Table A–5 continued

	GOAL IV			*GOAL V*			*GOAL VI*			*GOAL VII-p*		
Input	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*
	Structural	*Reduced Form*		*Structural*	*Reduced Form*		*Structural*	*Reduced Form*		*Structural*	*Reduced Form*	
Exogenous												
LIBRARY	1.489	3.260	3.334	2.522	5.857	3.039		1.032	-1.965		0.426	0.424
	(0.887)	(1.191)	(1.996)	(1.167)	(2.231)	(3.434)		(0.712)	(1.874)		(0.300)	(1.021)
TPPOS	0.514	0.660	-3.548		0.506	-5.145		0.135	0.238		0.029	-2.356
	(0.849)	(1.122)	(1.764)		(0.883)	(3.035)		(0.247)	(1.657)		(0.063)	(0.902)
TCOLLEGE		-3.801	-6.379	-0.592	-6.161	-12.065		-0.777	0.812		-1.759	-3.750
		(2.243)	(3.775)	(2.663)	(4.759)	(6.496)		(1.331)	(3.546)		(0.922)	(1.931)
TLOCALE		-1.439	1.848	-2.691	-4.685	-11.090		-0.683	-1.601		0.366	-0.580
		(1.239)	(4.652)	(1.965)	(3.498)	(8.005)		(0.727)	(4.369)		(0.333)	(2.380)
TSTABL	-3.892	-4.552	0.582		-2.496	13.154		-0.598	4.010		-0.101	2.823
	(1.653)	(2.196)	(5.677)		(2.250)	(9.769)		(0.841)	(5.332)		(0.312)	(2.904)
TMEDUC		-0.060	3.114		-0.488	3.314		-0.273	1.148		0.031	0.034
		(0.270)	(1.331)		(0.637)	(2.290)		(0.298)	(1.250)		(0.135)	(0.681)
REACTL		-0.045	-1.175		-0.367	-0.857		-0.205	-0.375		0.024	-0.332
		(0.200)	(0.774)		(0.417)	(1.331)		(0.184)	(0.727)		(0.101)	(0.396)
RECIDEA		2.019	2.824		2.969	0.789		0.365	0.041		0.971	1.062
		(1.072)	(1.504)		(1.663)	(2.587)		(0.683)	(1.412)		(0.482)	(0.769)
TCAREER		0.256	-0.449		0.352	-1.057		0.031	-1.120		0.184	-0.213
		(0.171)	(0.693)		(0.255)	(1.193)		(0.092)	(0.651)		(0.112)	(0.355)

TSATISF	*0.396* *(0.248)*	*0.683* *(0.337)*	*0.496* *(0.591)*		0.630 (0.333)	-0.055 (1.016)		0.125 (0.109)	0.289 (0.555)		0.148 (0.088)	0.121 (0.302)
DISCREP		-0.008 (0.020)	-0.382 (1.072)		-0.013 (0.034)	-3.452 (1.845)		-0.001 (0.023)	-0.692 (1.007)		-0.005 (0.010)	-0.151 (0.549)
CLPRACT		-0.136 (0.093)	0.174 (0.310)		-0.187 (0.138)	-0.189 (0.533)		-0.016 (0.049)	-0.080 (0.291)		-0.098 (0.061)	0.077 (0.159)
TSLARY	0.001 (0.001)	0.002 (0.001)	0.002 (0.001)		0.002 (0.001)	0.001 (0.002)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	0.0002 (0.0002)	0.001 (0.0004)	0.001 (0.001)
TEXPER		-0.020 (0.073)	0.660 (0.324)		-0.135 (0.153)	0.620 (0.558)		-0.074 (0.067)	-0.067 (0.305)		0.006 (0.036)	0.175 (0.166)
TEDUC		0.956 (0.778)	2.268 (2.401)		2.236 (1.472)	6.172 (4.132)		0.820 (0.692)	-1.045 (2.255)		0.370 (0.365)	1.461 (1.229)
EFFORT		-0.018 (0.050)	-0.236 (0.144)		-0.033 (0.092)	-0.377 (0.248)		-0.013 (0.040)	-0.159 (0.136)		-0.009 (0.023)	-0.172 (0.074)
STAFFP		7.842 (11.26)	-60.030 (97.493)		14.88 (19.39)	-277.316 (167.766)		6.163 (13.11)	51.053 (91.570)		3.713 (4.979)	-44.751 (49.877)
BOOKSP		-0.027 (0.026)	-0.191 (0.172)		-0.037 (0.037)	-0.071 (0.297)		-0.003 (0.010)	-0.017 (0.162)		-0.019 (0.018)	-0.159 (0.088)
GUIDANCE		119.7 (619.7)	763.838 (1172.361)	-698.117 (840.144)	-506.6 (1608.00)	1825.001 (2017.403)		-75.97 (386.1)	1585.325 (1101.135)		244.2 (264.6)	433.757 (599.779)
INNOVATE		0.026 (0.018)	0.140 (0.188)		0.036 (0.026)	0.072 (0.202)		0.003 (0.009)	-0.025 (0.110)		0.019 (0.012)	0.029 (0.060)
ADA		0.001 (0.001)	-0.003 (0.002)	0.003 (0.001)	0.004 (0.003)	-0.003 (0.004)		0.001 (0.001)	-0.001 (0.002)		0.0001 (0.001)	-0.002 (0.001)
CUG		-0.144 (0.061)	0.132 (0.079)	-0.081 (0.062)	-0.319 (0.116)	0.084 (0.135)	-0.075 (0.047)	-0.133 (0.048)	-0.044 (0.074)		-0.061 (0.026)	0.048 (0.040)
PRCO		5.000 (3.372)	5.369 (0.654)		11.82 (6.852)	13.748 (16.613)		3.893 (2.707)	-4.080 (9.068)	3.680 (1.615)	5.658 (2.278)	2.067 (4.939)
TLOD		-0.453 (0.029)	-0.228 (0.317)	0.012 (0.222)	-0.809 (0.355)	-0.572 (0.546)	-0.330 (0.168)	-0.566 (0.173)	-0.608 (0.298)		-0.190 (0.085)	-0.186 (0.162)

Table A–5 continued

Input	*GOAL IV*			*GOAL V*			*GOAL VI*			*GOAL VII-p*		
	Simultaneous System		*OLS*	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*
	Structural	*Reduced Form*		*Structural*	*Reduced Form*		*Structural*	*Reduced Form*		*Structural*	*Reduced Form*	
CSIZ		-0.035 (0.052)	0.053 (0.178)	-0.052 (0.069)	-0.110 (0.130)	0.079 (0.306)		-0.021 (0.033)	0.001 (0.167)		-0.008 (0.023)	0.039 (0.091)
AEE	-0.013 (0.016)	-0.017 (0.0210)	-0.043 (0.032)		-0.017 (0.022)	-0.011 (0.055)	0.021 (0.116)	0.014 (0.015)	0.018 (0.030)		-0.002 (0.004)	0.005 (0.016)
BRAT	-2.003 (1.348)	-1.295 (1.542)	-4.367 (2.044)		1.236 (1.830)	-8.102 (3.517)	1.824 (1.378)	2.361 (1.229)	0.226 (1.920)		0.143 (0.427)	-0.676 (1.046)
AMAN		0.534 (0.246)	-0.275 (0.302)	0.564 (0.189)	1.363 (0.423)	0.476 (0.520)		0.252 (0.172)	-0.042 (0.284)		0.214 (0.090)	-0.116 (0.155)
AXMAN	-0.086 (0.115)	-0.249 (0.155)	-0.020 (0.276)	-0.008 (0.149)	-0.246 (0.265)	-0.501 (0.475)	0.122 (0.114)	-0.213 (0.110)	-0.286 (0.259)		-0.075 (0.048)	0.035 (0.141)
SFRAT	0.0004 (0.060)	-0.031 (0.074)	0.022 (0.158)		-0.064 (0.085)	-0.130 (0.272)	-0.093 (0.051)	-0.119 (0.051)	-0.097 (0.149)	0.056 (0.020)	0.056 (0.031)	0.048 (0.081)
PSUP		-0.005 (0.003)	-0.009 (0.006)		-0.005 (0.006)	0.001 (0.011)	-0.011 (0.005)	-0.012 (0.004)	-0.008 (0.006)		-0.002 (0.001)	-0.004 (0.003)
SEFAC 1	-0.406 (0.516)	-0.954 (0.532)	-1.577 (0.871)	-2.185 (0.452)	-3.176 (0.888)	-3.155 (0.1499)	0.803 (0.742)	0.317 (0.384)	0.458 (0.818)	0.379 (0.138)	0.366 (0.220)	0.470 (0.446)
SEFAC 2	-0.381 (0.389)	-1.159 (0.382)	-0.236 (0.702)	-0.408 (0.389)	-1.626 (0.565)	-0.704 (1.208)	-0.446 (0.384)	-0.857 (0.261)	-0.875 (0.659)	0.265 (0.150)	-0.004 (0.164)	0.438 (0.359)
SEFAC 3	0.123 (0.294)	0.334 (0.379)	0.395 (0.490)	0.452 (0.315)	0.981 (0.578)	-0.329 (0.844)	0.301 (0.305)	0.447 (0.269)	0.599 (0.461)	-0.117 (0.109)	-0.140 (0.151)	-0.194 (0.251)
SEFAC 4	0.037 (0.338)	0.539 (0.358)	0.533 (0.516)	0.110 (0.386)	0.955 (0.550)	0.885 (0.880)	0.817 (0.321)	0.983 (0.246)	1.255 (0.484)	-0.250 (0.120)	-0.112 (0.155)	-0.310 (0.264)

INTERCEPT	-12.447 (33.292)	91.11 (15.80)	52.624 (37.434)	-17.663 (66.237)	163.4 (31.60)	208.843 (64.417)	80.699 (41.545)	136.8 (8.468)	149.627 (35.160)	8.196 (14.885)	54.43 (5.470)	57.914 (19.151)
R-SQUARE	0.715		0.843	0.856		0.823	0.715		0.833	0.645		0.711
F	5.157		2.610	10.291		2.254	4.008		2.427	6.047		1.194
SEE	1.596		2.090	1.838		3.596	1.454		1.963	0.671		1.069
Endogenous												
GOAL I				0.399 (0.090)			0.616 (0.313)					
GOAL II												
GOAL III-v				0.079 (0.148)								
GOAL III-m				-0.133 (0.115)								
GOAL IV							-0.083 (0.158)					
GOAL V	-0.273 (0.158)			0.031 (0.032)			0.292 (0.108)					
GOAL VI	0.162 (0.282)			0.072 (0.047)			0.137 (0.172)					
GOAL VII-p	0.811 (0.512)			-0.127 (0.163)			1.212 (0.393)			1.090 (0.420)		
GOAL VII-o												
GOAL VIII							-1.479 (0.567)					
GOAL IX				0.003 (0.070)						-0.097 (0.150)		
GOAL X							0.270 (0.144)					

Table A–5 continued

Input	GOAL IV			GOAL V			GOAL VI			GOAL VII-p		
	Simultaneous System		OLS	Simultaneous System		OLS	Simultaneous System		OLS	Simultaneous System		OLS
	Structural	Reduced Form		Structural	Reduced Form		Structural	Reduced Form		Structural	Reduced Form	
Exogenous												
LIBRARY		-1.085 (0.887)	2.810 (2.965)		0.359 (0.269)	-0.271 (0.609)		1.872 (1.150)	3.238 (2.447)		0.282 (0.315)	3.238 (2.447)
TPPOS		-0.093 (0.171)	-1.104 (2.621)		0.037 (0.071)	-0.479 (0.538)		0.119 (0.260)	-5.123 (2.163)		0.020 (0.047)	-5.123 (2.163)
TCOLLEGE		0.127 (1.388)	-0.814 (5.609)		-0.420 (0.511)	-1.562 (1.152)	-4.113 (1.969)	-8.122 (3.539)	-11.197 (4.630)		-1.129 (1.160)	-11.197 (4.630)
TLOCALE		0.870 (0.907)	-1.047 (6.912)		-0.269 (0.269)	-0.729 (1.420)		-1.630 (1.387)	-2.727 (5.705)		-0.240 (0.303)	-2.727 (5.705)
TSTABL	-2.741 (2.193)	-2.239 (2.305)	3.140 (8.435)		-0.185 (0.258)	1.838 (1.733)		-0.416 (1.221)	3.460 (6.962)		-0.070 (0.238)	3.460 (6.962)
TMEDUC		0.114 (0.175)	0.896 (1.978)	-0.247 (0.188)	-0.368 (0.302)	0.141 (0.406)		0.280 (0.410)	0.623 (1.632)		0.007 (0.124)	0.623 (1.632)
REACTL		0.086 (0.120)	-1.346 (1.150)	-0.186 (0.102)	-0.277 (0.150)	0.062 (0.236)		0.211 (0.285)	-0.720 (0.949)		0.005 (0.093)	-0.720 (0.949)
RECIDEA		0.037 (0.622)	5.107 (2.234)		0.204 (0.267)	0.796 (0.459)	2.406 (0.934)	4.511 (1.748)	2.366 (1.844)		0.621 (0.634)	2.366 (1.844
TCAREER		0.059 (0.116)	0.532 (1.030)		0.012 (0.036)	-0.099 (0.212)		0.597 (0.323)	-0.459 (0.850)	0.868 (0.326)	1.011 (0.389)	-0.459 (0.850)
TSATISF		-0.032 (0.117)	-0.435 (0.877)		0.037 (0.037)	0.082 (0.180)		0.499 (0.278)	1.096 (0.724)	0.592 (0.258)	0.705 (0.301)	1.096 (0.724)
DISCREP		-0.0001 (0.004)	3.922 (1.593)		-0.003 (0.012)	-0.025 (0.327)		-0.013 (0.029)	-0.696 (1.315)		-0.004 (0.009)	-0.696 (1.315)

CLPRACT		-0.031 (0.062)	0.020 (0.461)		-0.007 (0.019)	-0.139 (0.095)		-0.317 (0.177)	-0.116 (0.380)	-0.460 (0.172)	-0.536 (0.214)	-0.116 (0.380)
TSALARY	0.002 (0.001)	0.002 (0.001)	0.002 (0.002)	0.0003 (0.0002)	0.001 (0.0002)	0.001 (0.0004)	0.001 (0.001)	0.002 (0.001)	-0.0001 (0.002)		0.001 (0.0004)	-0.0001 (0.002)
TEXPER		0.030 (0.042)	0.565 (0.482)	-0.064 (0.038)	-0.099 (0.056)	-0.075 (0.099)		0.068 (0.100)	1.087 (0.398)		0.001 (0.033)	1.087 (0.398)
TEDUC	-2.427 (1.672)	-2.604 (1.833)	-4.041 (3.568)		0.436 (0.347)	-0.283 (0.733)		1.124 (0.931)	5.833 (2.945)		0.294 (0.348)	5.833 (2.945)
EFFORT		-0.0001 (0.007)	-0.102 (0.215)		-0.011 (0.031)	-0.006 (0.044)		-0.023 (0.061)	-0.538 (0.177)		-0.007 (0.020)	-0.538 (0.177)
STAFFP		-0.046 (3.365)	-22.902 (144.865)		5.070 (6.697)	-13.235 (29.763)		9.563 (13.17)	-246.239 (119.563)		3.118 (4.42)	-246.239 (119.563)
BOOKSP		-0.006 (0.018)	0.348 (0.256)		-0.001 (0.004)	0.003 (0.053)		-0.062 (0.056)	-0.518 (0.211)	-0.090 (0.074)	-0.105 (0.085)	-0.518 (0.211)
GUIDANCE		323.9 (341.5)	1482.909 (1742.025)		-9.098 (236.5)	822.741 (357.901)		655.9 (821.3)	2325.712 (1437.762)	1453.498 (472.002)	1656.0 (585.2)	2325.712 (1437.762)
INNOVATE		0.006 (0.012)	0.323 (0.175)		0.001 (0.004)	0.015 (0.036)		0.061 (0.034)	0.095 (0.144)	0.088 (0.036)	0.103 (0.042)	0.095 (0.144)
ADA		-0.001 (0.001)	0.00005 (0.004)		0.0004 (0.003)	-0.001 (0.001)	-0.002 (0.001)	-0.004 (0.002)	-0.005 (0.003)	0.001 (0.001)	0.001 (0.001)	-0.005 (0.003)
CUG		0.016 (0.053)	-0.012 (0.117)	-0.025 (0.010)	-0.059 (0.019)	-0.029 (0.024)	-0.024 (0.044)	-0.208 (0.083)	0.052 (0.097)	-0.169 (0.041)	-0.216 (0.049)	0.052 (0.097)
PRCO		1.998 (3.476)	4.807 (14.345)	3.805 (0.891)	5.169 (1.421)	2.589 (2.947)		6.472 (5.320)	6.980 (11.840)		5.537 (2.835)	6.980 (11.840)
TLOD	0.103 (0.229)	0.078 (0.245)	0.478 (0.471)	-0.072 (0.040)	-0.233 (0.060)	-0.195 (0.097)	-0.204 (0.151)	-0.656 (0.283)	-0.677 (0.389)	-0.231 (0.169)	-0.374 (0.193)	-0.667 (0.389)
CSIZ	0.063 (0.080)	0.083 (0.084)	0.197 (0.265)	0.007 (0.015)	-0.002 (0.024)	0.117 (0.054)		-0.039 (0.079)	0.127 (0.218)	0.037 (0.055)	0.032 (0.066)	0.127 (0.218)
AEE		0.005 (0.007)	0.004 (0.047)		-0.002 (0.005)	0.002 (0.010)		-0.006 (0.012)	-0.001 (0.039)		-0.002 (0.003)	-0.001 (0.039)

Table A–5 continued

Input	*GOAL VII-o*			*GOAL VIII*			*GOAL IX*			*GOAL X*		
	Simultaneous System		*OLS*	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*	*Simultaneous System*		*OLS*
	Structural	*Reduced Form*		*Structural*	*Reduced Form*		*Structural*	*Reduced Form*		*Structural*	*Reduced Form*	
BRAT	-5.959 (1.844)	-5.798 (1.829)	-2.063 (3.037)		0.215 (0.256)	-0.168 (0.624)		0.669 (1.106)	-3.848 (2.507)		0.090 (0.390)	-3.848 (2.507)
AMAN		-0.157 (0.200)	-0.032 (0.449)		0.139 (0.066)	0.030 (0.092)		0.749 (0.289)	0.161 (0.370)	0.377 (0.136)	0.538 (0.193)	0.161 (0.370)
AXMAN	-0.265 (0.151)	-0.293 (0.163)	0.464 (0.411)	0.023 (0.026)	-0.075 (0.044)	-0.081 (0.084)		-0.211 (0.144)	-0.068 (0.339)		-0.062 (0.049)	-0.068 (0.339)
SFRAT		0.044 (0.050)	0.035 (0.235)		-0.024 (0.017)	-0.105 (0.048)	-0.091 (0.054)	-0.012 (0.084)	-0.105 (0.194)		0.063 (0.039)	-0.105 (0.194)
PSUP	0.007 (0.006)	0.006 (0.006)	-0.003 (0.010)		-0.001 (0.001)	0.0001 (0.002)		-0.007 (0.004)	-0.015 (0.008)	-0.004 (0.003)	-0.006 (0.004)	-0.015 (0.008)
SEFAC 1	-0.083 (0.686)	1.132 (0.53)	0.495 (1.295)	0.050 (0.142)	-0.035 (0.152)	-0.017 (0.266)	0.047 (0.415)	-0.176 (0.678)	0.077 (1.068)	-0.452 (0.387)	-0.036 (0.401)	0.077 (1.068)
SEFAC 2	0.163 (0.448)	0.465 (0.415)	1.608 (1.043)	0.268 (0.083)	-0.056 (0.111)	-0.067 (0.214)	-0.375 (0.340)	-1.052 (0.425)	0.643 (0.861)	0.081 (0.296)	0.179 (0.307)	0.643 (0.861)
SEFAC 3	-0.507 (0.407)	-0.816 (0.397)	-1.500 (0.729)	0.045 (0.068)	0.097 (0.103)	0.096 (0.150)	0.017 (0.246)	-0.039 (0.390)	-0.573 (0.601)	-0.058 (0.243)	-0.207 (0.275)	-0.573 (0.601)
SEFAC 4	-0.456 (0.456)	-0.648 (0.409)	-0.547 (0.766)	-0.011 (0.086)	0.106 (0.093)	0.179 (0.157)	0.587 (0.296)	0.695 (0.399)	-0.173 (0.633)	0.266 (0.282)	-0.077 (0.277)	-0.173 (0.633)
INTERCEPT	126.113 (43.250)	147.9 (15.87)	69.329 (55.624)	41.549 (9.111)	84.99 (3.458)	88.020 (11.428)	68.489 (39.908)	150.4 (17.41)	175.344 (45.908)	54.757 (20.535)	99.47 (9.420)	175.344 (45.908)
R-SQUARE	0.505		0.711	0.815		0.806	0.818		0.797	0.595		0.797
F	2.521		1.195	7.032		2.020	8.468		1.907	2.779		1.907
SEE	2.301		3.106	0.353		0.638	1.376		2.563	1.407		2.563

Glossary

ADA	Average daily attendance
AEE	Extracurricular expenditures per pupil
AMAN	Administrative manhours per student
AXMAN	Auxiliary manhours per student
ATTEND	Number of days students were absent in past year
BOOKSP	Library books per pupil
BRAT	Ratio of building enrollment to state rated capacity
CLPRACT	Extent of use of innovation, as perceived by teachers
COUNSEL	Access to guidance staff
CSIZ	Class size
CUG	Curriculum units per grade
DISCREP	Discrepancy between what teachers see as the actual and the ideal influences various groups have on school policy
EFFORT	Property taxes divided by property valuation per pupil
ENROLL	School enrollment
EQA	Educational quality assessment
FAMSES	Family socioeconomic status
FOCC	Occupation of student's father
GOAL I	Self concept
GOAL II	Understanding others
GOAL III-v	Verbal basic skills
GOAL III-m	Mathematical basic skills
GOAL IV	Interest in school
GOAL V	Citizenship
GOAL VI	Health habits
GOAL VII-p	Creativity potential

GOAL VII-o	Creativity output
GOAL VIII	Vocational development
GOAL IX	Appreciation of human accomplishments
GOAL X	Preparation for change
GUIDANCE	Number of guidance counselors per pupil
HOLDING	Inverse of the dropout rate
HOUSING	Index of types of housing in the community
INNOVATE	Extent of use of innovation, as perceived by the administration
INSEXADM	Instructional expenditures per pupil in average daily membership
INTERRAC	Students' contact with persons of races different from their own
LIBRARY	Students' accessibility to library
LOCATION	Index of type of community in which school is located
MOCC	Occupation of student's mother
MORESB	Boys' mores
MORESG	Girls' mores
OCDESIRE	Occupational desire of students
OCEXPECT	Occupational expectation of students
OLS	Ordinary least squares
PCTMW	Percent of students' mothers working
PDE	Pennsylvania Department of Education
POSTGRAD	Postsecondary education of students graduating in past two years
PRCO	Preparation coefficient for teachers
PSUP	Paraprofessional manhours per student
RACE	Students' race
REACTL	Teachers' perception of *actual* characteristics influencing professional recognition
RECIDEA	Teachers' perception of *ideal* characteristics influencing professional recognition
SEFAC	Socioeconomic factor
SEX	Student sex
SFRAT	Student to academic faculty ratio
STAFFP	Ratio of instructional staff to pupils
SUBSIDY	State aid to school district per pupil in average daily membership
TAGE	Teachers' age
TCAREER	Teachers' career aspirations
TCOLLEGE	Index of type of college from which teachers received a degree
TEDUC	Teacher's educational preparation
TEXPER	Teachers' experience
TFEDUC	Education level of teachers' father

TLOCALE	Type of town where teachers lived while in high school
TLOD	Teaching load per teacher
TMEDUC	Education level of teachers' mother
TPPOS	Teachers' tenure in present position
TSALARY	Average teachers' salary
TSATISF	Teachers' satisfaction with his role in school
TSEX	Teachers' sex
TSTABL	Teachers' locational stability
VALUES	Index of students' personal values

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